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The Impact of Ongoing Science Professional Development on Standardized Assessments of Student Achievement

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THE IMPACT OF ONGOING SCIENCE PROFESSIONAL DEVELOPMENT ON STANDARDIZED ASSESSMENT OF STUDENT ACHIEVEMENT

by

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ABSTRACT

The purpose of this study was to identify how ongoing science professional development impact students' achievement on standardized assessments. The students' end-of-year assessment and State Science Assessment data were collected from a Central Florida school district. The student data were divided into categories based on teachers' participation in on-going professional development opportunities. The teachers were categorized by the number of types of professional development opportunities they attended. The mean assessment scores of students whose all teachers did or did not participate were calculated, and *t*-tests were run to find the significance between the means. There was no significance in the difference between the means student scores of the participants and the non-participants in the science professional development opportunities. Two sub group data, 8th-grade free and reduced lunch students whose teacher attended one professional development, and 7th-grade students who scored a Level 3 on FSA mean scores on the science assessments scores were higher with significance in the 2015-16 school year, and were not higher the on the science assessments with significance in the 2014-15 school year.

I dedicate this dissertation to my parents, my husband, and my children.

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THE PROBLEM AND ITS CLARIFYING COMPONENTS

Background of the Study

With the increased focus on science education, including the emergence of Science, Technology, Engineering, and Mathematics (STEM) schools and magnet programs, high expectations for student achievement in science has put additional pressure and responsibility on science educators. Since the beginning of the 21st century, there has been an increased emphasis on the science standards and an introduction of standardized science assessments (Florida Department of Education [FDOE], 2016). Success in science has been measured in Florida by standardized assessments that assess the science standards in Grades K-5, 6-8, and high school Biology (FDOE, 2016). Florida middle school science course standards are concerned with space science/earth science, physical science, life science, and the nature of science, all skills scientists use to study science ("CPALMS," 2013). Legislation has begun to introduce engineering standards into the content areas courses changing the expectations for teaching science courses ("CPALMS," 2013). The topics covered in middle school science courses build the foundation for students to be successful in high school and college science courses ("CPALMS," 2013).

In 2015 in the state of Florida, only 49% of students passed the 8th-grade Statewide Science Assessment (SSA; FDOE, 2015b). The topics on the test cover standards that are taught in 6th, 7th- and 8th-grade (FDOE, 2012). In a county in central Florida, in 2015 the pass rate for the 8th-grade science assessment was only 39%, which is 10 percentage points lower than the state of Florida (FDOE, 2015b). All 8th-grade students in Florida have been required to take the

8th-grade Statewide Science Assessment unless they have been enrolled in the high school Biology (FDOE, 2012).

The course standards for 6th-, 7th- and 8th-grade courses are assessed on the 8th-grade Statewide Science Assessment (FDOE, 2015b). The middle school science courses in Florida do not include prior year standards ("CPALMS," 2013), and student demographics and summer negative impact can impact the amount of information retained from one year to the next (Palardy & Peng, 2015).

The central Florida school district that was the focus of this study had a high percentage of high needs students. A total of 65% of students in a central Florida school district received free and reduced lunch (FDOE, 2016). Socio economic status of students has been shown to have an effect size of .58, indicating that it has a large impact on student success (Hattie, 2009), and high needs students (e.g., lower socio economic status) have been shown to be negatively impacted more by a summer vacation (Hattie, 2009). According to Palardy and Peng (2015), the students lose information over the summer, and the standards are not spiraled the following year.

Reading levels associated with students with disabilities and English Language Learners have a direct impact on student performance on science tests. In 2008, a total of 18% of students in one county in a central Florida school district were English Language Learners, and science vocabulary and reading passages have been noted to be difficult for students with disabilities and ELL students (Luykx, Lee, & Edwards, 2008).

There are multiple paths to obtaining science teaching certification in Florida. Table 1 shows the different areas of science and the respective grade levels for which individuals can seek certification as science teachers in Florida (FDOE, 2016).

Table 1

Middle School Science Certification by Subject Area and Grade Level

Subject Area	Grade Levels
Elementary Education	K-6
Middle Grades Science	5-9
Biology	6-12
Chemistry	6-12
Earth/Space Science	6-12
Physics	6-12

Source. FDOE, 2016.

There are multiple paths to obtaining these science certifications. Individuals could have a degree one of the science fields and receive certification based on credit hours of course work. They could also have earned a bachelor's degree in another field, but qualify for certification based on a subject area assessment (Florida Statute 1012.56, 2011).

The nature of science standards included in all of the middle school courses are the skills that scientists use to learn science content, ideally through an inquiry model. Inquiry is learning through asking questions, generating hypothesis, planning, investigating, analyzing, evaluating and making conclusions (Zervas, Sotiriou, Tiemann, & Sampson, 2015). Inquiry skills to solve problems would be an example of a skill needed in science that teachers may not have. Teachers who have not been trained in teaching science through inquiry or who have not experienced learning through inquiry may find this method difficult to implement, regardless of the benefit to students (Peters-Burton, Merz, Ramirez, & Saroughi, 2015). Middle school science teachers may not be trained in gathering information using inquiry, making it difficult for a teacher to use that method to teach specific science content (Peters-Burton et al., 2015). Different models of inquiry have emerged from constructivism or the idea that students learn information by constructing mental models or reconstructing mental models to learn the information. The content information is not memorized through lecture but is constructed through inquiry (Zervas et al., 2015).

Though teachers may have pedagogical knowledge, content knowledge and a solid grounding in teaching, including inquiry methods, they may struggle with collaboration because teachers often compete (McCaffrey, 2012). Collaboration among teachers, specifically through professional learning communities (PLCs) when teacher meet and collaborate, may be less likely even though it has been shown to have a positive impact on student performance (Kelly & Cherkowski, 2015).

Professional development is an opportunity for science teachers to increase content knowledge and/or pedagogical knowledge in a specific area. It has been used in Florida to help in-service teachers continually learn, and it has been required for certification renewal (Florida Statute 1012.56, 2011). Effective professional development is characterized by certain elements. Through a meta-analysis study, the characteristics of sound professional development were found to be: (a) content focus, (b) amount of time given for the professional development, (c) longer duration of professional development, (d) multiple activities during the professional development, (e) learning goals set for professional development, and (f) the participation of teachers (Blank, 2013).

Professional development for science content knowledge can help teachers bridge the gap in their knowledge and develop a greater understanding of the content they are teaching. The study of the effectiveness of science content professional development has been focused on preservice more than in-service teachers (Diamond, Maerten-Rivera, Rohrer, & Lee, 2014).

According to Diamond et al. (2104), teachers' science content knowledge has a direct impact on science achievement with the variances in science achievement being attributed to difference in teacher qualifications. These researchers reported that the number of science courses a science teacher completed in college was shown to have impact on student achievement, along with teaching experience and the highest degree a teacher has earned.

A concern with science professional development in regard to science content knowledge is the difficulty of measuring the direct impact professional development has on student achievement. The National Science Foundation has tried to design instruments to measure teacher and student content knowledge, teacher beliefs about science instruction, and to gauge student opportunities to learn science ideas (Trygstad, Banilower, Smith, & Nelson, 2014). The instruments were designed to measure student achievement beyond simply reviewing standardized assessments.

Professional development for introducing collaboration in the PLC model has been researched. Kelly & Cherkowski (2015) studied the professional development of reading teachers in the process of learning how to collaborate in a PLC. The teachers at first were uncomfortable in the collaborative environment, but throughout the year they developed a "sense of interdependence" (Kelly & Cherkowski, 2015, p. 16). The increase in collaboration caused a change in teaching practices and, in turn, led to an increase in student achievement. Jeanpierre, Oberhauser, and Freeman (2005) expressed the belief that professional development in the areas of science content knowledge and professional learning communities would help improve student achievement. They believed that professional development allowed teachers to gain content knowledge and develop instructional strategies that they could use in the classroom environment to more effectively teach science and improve science achievement. Sahin (2014) observed that effective science instructors have pedagogy skills and inquiry skills to teach the content and help students master the content information.

Multiple types of professional development are needed for Florida middle school science teachers to help even out the differences in skill levels due to the various pathways to certification, which can lead to changes in “teacher knowledge and beliefs, which leads to improved classroom practice, and ultimately better student outcomes” (Trygstad et al., 2014, p. 1). Middle school science teachers’ strengths and weakness can vary due to their preparation pathways leading to certification, and professional development can help them develop in their areas of weaknesses, (e.g., pedagogy, content). Professional development, according to Diamond et al. (2014), has been shown to increase “teacher’s confidence in teaching science” (p. 636).

Statement of the Problem

There has been a paucity of research concerning the effectiveness of in-service training through professional development for in-service middle school science teachers. Specifically, there has been a lack of research concerning the effectiveness of content based professional development for middle school science teachers and in the determination of how multiple types of professional development impact student achievement on standardized tests. The research study was limited to professional development for middle school science teachers that are individually analyzed for effectiveness in increasing student achievement on standardized tests.

Professional development for teachers is important for teacher growth and student performance. Teachers’ content and pedagogical knowledge impact students’ foundational knowledge of science for future classes (Sahin, 2014). Compounded with student issues such as socio-economic status, English Language Learner status (Lyukx et al., 2008), reading levels, and summer vacation, there is a large gap in what middle school students are taught, how they are taught, and how much information they learn in science (Diamond et al., 2014). This research can help in understanding how professional development for middle school science teachers in multiple areas, including content knowledge, pedagogical knowledge, and collaboration impact overall student achievement on standardized assessments. Professional development opportunities are not normally measured by outcomes such as improvement to students' achievement levels on standardized assessments.

Significance of the Study

Teachers involved in the study have participated in a grant that includes content, pedagogical professional development, and collaborative professional development. The research helped in determining if a teacher attended professional development opportunities impacted students' scores on standardized assessments.

> In the past, there was very little research available on practicing teacher SCK (science content knowledge), and how it relates to student achievement. This in spite of the fact that lack of SCK is often cited as a 'primary cause of the inability of teachers to teach science effectively. (Diamond et al., 2014, p. 636)

Pedagogical content knowledge has been studied more than science content knowledge, possibly because pedagogical knowledge "is more often described as being more directly related to teaching than CK (content knowledge)" (Diamond et al., 2014, p. 636). A part of the science content knowledge that is often addressed separately and studied separately is the use of science skills in learning and teaching science.

In this study, the professional development encompassed science content knowledge, pedagogical content knowledge, science skills in learning science content, and professional learning communities collaborating together. Each piece of the professional development opportunities was examined to determine if there was a significant statistical difference in student achievement levels when teachers participate in science professional development opportunities. Each component of the professional development was designed to build upon another component to increase student achievement, thus, the researcher sought to identify any combination of factors that worked together to increase student science achievement for those teachers involved in the professional development. Each of the professional development sessions were designed to work together to increase student achievement. The focus of the research was to determine if the multiple professional development opportunities provided resulted in students of the participating teachers having statistically and significantly different levels of achievement than students who did not have a teacher participating in the grant. Diamond et al. (2014) posited that teachers undergoing professional development to help increase their pedagogical knowledge or science content knowledge would have an impact on student achievement. An increase in student achievement would help students as they move on to high school and college science courses, preparing them with the science inquiry skills and content information to be successful.

Purpose Statement

The purpose of the study was to determine if ongoing professional development in pedagogical strategies, collaboration strategies, and science content impacts student learning as evidenced by an increase in achievement in science content. Increased achievement was measured using scale scores on the school district end-of-year examinations or the statewide science assessment. The researcher examined the relationship between science content professional development and pedagogical professional development and how professional development impacted student achievement. Also examined was the extent to which ongoing professional development that encouraged collaboration in content areas impacted collaboration among middle school science teachers and resulted in an increase in student achievement for students.

Definitions

The following operational definitions are provided for key terms used in the research process.

Andragogy: The art and science of helping adults learn (Ntombela, 2015).

Constructivism: Learning content by shaping and reshaping of mental models by learners (Khourey-Bowers & Fenk, 2009).

Professional Learning Communities (PLC): Effective organizational approach for providing teacher with the opportunity to collaborate to improve their practice (Kelly & Cherkowski, 2015).

Pedagogy Knowledge: Teaching practices that are effective for students to understand a specific subject matter (Diamond et al., 2014).

Professional Development: Training that improves teachers' knowledge, practice and student outcomes to improve teacher content and improve the theory of instruction (Diamond et al., 2014).

Science Content Knowledge: Teacher knowledge of specific science content (Diamond et al., 2014).

Science Skill Inquiry Practices: The inquiry cycle in science that includes the following steps: orienting and asking questions, hypothesis generation and design, planning and investigation, analysis and interpretation, conclusion and evaluation (Zervas et al., 2015).

Social Constructivism: where learners learn more through their collaboration with each other than they would have alone in the learning process (Wang & Ha, 2016).

Conceptual Framework

The three theoretical frameworks on which the middle school science teachers' professional development opportunities in the study were based include (a) andragogy, (b) constructivism, and (c) social constructivism. Andragogy is the study of how adults learn and was first researched by Kapp (Ntombela, 2015). Constructivism is based on Piaget's work that places importance on model building, a dynamic cognitive process in which the learner assigns specific attributes to the object of learning (Piaget & Inhelder, 1969). Social constructivism differs in the emphasis in the importance of the dialogue in the process of learning information, not the information itself (Khourey-Bowers & Fenk, 2009). The professional development opportunities focused on pedagogy, content, and collaboration, and all were grounded in the three frameworks of andragogy, constructivism, and social constructivism.

Adults learn differently than children, often informally in “clubs and social groups” (Ntombela, 2015, p. 31). Knowles (1984) described an andragogic model for adult learning. The six assumptions underpinning Knowles’ model are as follows:

1. Adults need to know why they are learning a topic.
2. Adults need to be willing to learn and not feel like it is forced upon them.
3. Adults have more experience to bring to the learning process.
4. Adults will learn to gain skills to manage problems or situations.
5. Adults learn using a “task-oriented” approach
6. Adult are motivated to learn intrinsically.

When adults are in learning environments, they are not necessarily dependent on the teacher for learning. Though teachers will guide adult learners to assist them, a key difference between andragogy and pedagogy is that andragogy is learner-focused and instructor-guided (Knowles, 1984). The structure of professional development for educators should follow the andragogic model, realizing the adult learner is motivated to learn and does not need direct instruction.

Constructivism is the idea that individuals learn through constructing “new knowledge from their prior experiences through a process of assimilation and accommodation” (Wang & Ha, 2011, p. 265). Constructivism is based on Piaget’s idea about how knowledge is constructed in the learning experience. “Knowledge is not brought about by empirical learning but simply constitutes the necessary condition for the organization and recording of the experience” (Piaget, 1971, p. 312). Piaget described learning as a process that includes interaction and organization of the topic being studied. The learning process of a learner might be to “come to see, understand, or experience a given phenomenon in a certain way" (Ekawati & Lin, 2014, p. 127). Teachers have to construct and reconstruct information or knowledge to learn themselves and to teach others. The learning process also includes "cognitive dissonance" (Deghaidy, 2015, p. 1580) to help them reconstruct pre-existing beliefs and practices which is the organization of the experience.

In science, constructivism allows learners to build a model to help build reality (Khourey-Bowers & Fenk, 2009). The models help individuals, adults or students, continually construct and build models to construct information. The process allows for continuous growth in learning. Constructivism is the model of learning for inquiry and problem based learning methods in science. Teachers can learn how to construct new content information using a constructivism model, then apply the constructivism model in their classrooms to teach content (Khourey-Bowers & Fenk, 2009).

Social constructivism allows individuals to learn through a Zone of Proximal Development, meaning they learn more by constructing information through interaction with each other individually (Vygotsky, 1978). Social constructivism allows growth in the learning process by interacting with others that have a better understanding of the concept. A person may not understand the entire process or may not have a deep level of understanding about a concept, but by working with others who do, the person will learn more because they are now outside their normal learning zone (Vygotsky, 1978). This idea can help learners learn more through their collaboration with each other than they would have alone in the learning process (Voogt & Laferriere, 2015). Social constructivism allows learning to occur in interactions and communication with others while processing new information or tasks (Wang & Ha, 2016).

Social constructivism focuses on the learning within a group that occurs in professional development opportunities (Voogt & Laferriere, 2015). Constructivism focuses on teachers building a model to learn new content information which is a part of professional development in science. Constructivism approaches in science professional development can increase the teachers' content knowledge and help integrate inquiry skills for teaching students (Khourey-Bowers & Fenk, 2009). Andragogy describes how adults learn information with different sets of assumptions than children. These constructs were all incorporated into the professional development model used in the research study.

Research Questions

The researcher questions were chosen to determine is the professional development opportunities middle school science teachers attended impacted standardized assessment scores.

1. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participated in three on-going professional development opportunities and the students whose teachers did not participate in three professional development opportunities throughout the 2015-16 school year?
2. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participated in two on-going professional development opportunities and the students whose teachers did not participate in two professional development opportunities throughout the 2015-16 school year?

3. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments of students whose middle school science teachers participates in one on-going professional development opportunity and those students whose teachers did not participate in one or less professional development opportunity throughout the 2015-16 school year?

Research Hypotheses

The null hypothesis for the first research question was that there was no statistically significant difference in student achievement for middle school science teachers who attended three professional development opportunities throughout the 2015-2016 school year and those who did not. The null hypothesis for the second research question was there was no statistical significant difference in student achievement for the teacher who attended two professional development opportunities throughout the school year and those who did not. The third null hypothesis was that there was no statistical significant difference in student achievement for the middle school science teachers who attended one professional development opportunity throughout the year and those who do not.

Variables

The variables of the study were the teachers participating in the ongoing professional development, the student achievement on the standardized test, and student growth in science skills from the science assessments. The independent variables for the research study were the teachers participating in the ongoing professional development in content, pedagogy, and collaboration. The dependent variables were (a) the students' scores on the state standardized assessment and(b) the students' scores on district created end-of-year examinations. Extraneous variables were (a) the teachers' days of participation in the professional development, (b) the students' attendance, and (c) student transfer in and out of science classes at the school site.

Limitations

One limitation of the study was related to the teachers' and students' mobility during the professional development cycle: (a) students who left in the middle of the school year, allowing difference in student population, and (b) teachers who left mid-year, creating a situation where a student began the school year with a teacher who attended professional development and finished a school year with one who did not,

A second limitation was related to administrative support for the implementation of the professional development. Teachers who had support from their administrators were more likely to implement changes and to show an increase in scores.

A third limitation is the different formats of professional development opportunities provided to the teachers.

Delimitations

The study focused on a central Florida school district that was participating in ongoing professional development through a grant.

The study was delimited to middle school teachers who were willing to participate in the professional development in the 2015-16 year.

The data gathered for the study were delimited to state science data for the 2015-16 school year. Eighth-grade Biology EOC data were not used in the study because 8th-grade

Biology students were accelerated, and most of the students score a level five on the examination. This would make analysis very difficult because the students had such high achievement levels.

Methodology

Middle school science teachers in a central Florida school district had an opportunity to participate in on-going professional development opportunity through a Math Science Partnership Grant. The study was quantitative, gathering student scale scores on the statewide science assessment, the 6th-grade Life Science end-of-year assessment, or the 7th-grade Earth Science/ Space Science end-of-year assessment.

Research Design

Middle school science teachers from various middle schools in a central Florida school district attended ongoing professional development opportunities through a Math Science Partnership grant. The researcher obtained the number of opportunities teachers attended during the grant period, and students' assessment information was analyzed for differences in student achievement based on the teacher participation in the professional development opportunities. The data were gathered from the Statewide Science Assessment, the 6th-grade Life Science end-of-year examination, and the 7th-grade Earth/Space Science end-of-year examination. The reliability and validity of each assessment were calculated. The assessments were analyzed to determine a statistical significance for students' achievement based on teachers who participated in either three, two or one professional development opportunities over the course of the school year.

Population and Sample

The population for the study were middle school science teachers from various middle schools in a central Florida school. The sample size for the research study was a convenience sample. The achievement of students of teachers who volunteered to participate in the professional development opportunities students was compared to that of students of teachers who did not participate in professional development opportunities

Data Collection

The assessment scale scores from the Statewide Science Assessment, the 6th-grade Life Science end-of-year examination, and the 7th-grade Earth/Space Science end-of-year assessment were gathered for analysis. The Statewide Science Assessment was administered through the state of FDOE. The assessment was a paper based assessment, and the district student report (DSR) was released through pearsonaccessnet.com. Permission was obtained to gather student scores from a central Florida school district. The 6th-grade Life Science assessment and the 7th-grade Earth/Space assessment was a paper-based assessment that was administered through the central Florida school district testing platform. Permission was obtained to gather the scores from the item bank and test platform (IBTP). The scores were normalized.

Data Analysis

The scale scores gathered from the assessments listed, and the scale scores from each of the assessments was converted into z scores. The scores were analyzed for statistical significance to determine if the professional development opportunities that middle school science teachers in a central Florida school district chose to attend impacted student achievement as measured by students' standardized assessments. Table 2 contains the research questions, the sources of data, and the variables

Table 2

Research Questions, Sources of Data, and Variables

	Research Questions	Sources of Data	Variables
1.	What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participate in three on going professional development opportunities and the students whose teachers did not participate in three professional development opportunities throughout the school year?	6th-grade end-of-year assessment 7th-grade end-of-year assessment Statewide standards assessment	Independent: Teacher participation in professional development Dependent: Student scale scores of students of teachers participating in the professional development
2.	What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participate in two on going professional development opportunities and the students whose teachers did not participate in two professional development opportunities throughout the school year?	6th-grade end-of-year assessment 7th-grade end-of-year assessment Statewide standards assessment	Independent: Teacher participation in professional development Dependent: Student scale scores
3.	What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participate in one on going professional development opportunities and the students whose teachers did not participate in one professional development opportunities throughout the school year?	6th-grade end-of-year assessment 7th-grade end-of-year assessment Statewide standards assessment	Independent: Teacher participation in professional development Dependent: Student scale scores

Organization of Study

The study has been organized into five chapters. In Chapter 1, the introduction, problem statement, theoretical framework, research questions, operational definitions, variables, limitations and delimitations are explained. Chapter 2 contains the literature review that focused on the science professional development for pedagogy and content with the theoretical framework of continuous learning through collaboration. Chapter 3 presents the methodology use to conduct the study, and Chapter 4 includes the results of the analysis of the data. Chapter 5 contains a summary and discussion of the findings along with recommendations based on the findings of the research.

CHAPTER 2
LITERATURE REVIEW

Introduction

The literature about educators and professional development shows a wide range of teacher skill level in teaching science. The science teachers' content knowledge and pedagogical knowledge have a direct impact on the student science success (Trygstad et al., 2014). The study's theoretical framework for the professional developments focused are social constructivism, constructivism, and andragogy. These frameworks create the basis for science educator professional development. Science educators can have a range of training and content knowledge when they begin teaching. In-service and pre-service programs are designed to strengthen new teachers' skills and help them remain in the teaching field (Cherubini, 2007). Ongoing professional development in science education dealing with pedagogical content knowledge based in inquiry, science content knowledge, and professional learning communities helps science educators stay active learners and have a positive impact on student achievement (Jeanpierre et al., 2005).

Science Certification in Teaching

At the time of the present study, there were multiple paths (i.e., alternative certification and traditional certification) to becoming a teacher in the United States. Traditional teachers are those who have been trained in the field of education but have not taught full time in a full time classroom, and an alternative certification teacher typically has a degree, but not in education, and wishes to pursue the option of becoming a classroom teacher. Different states have established different guidelines for the certification process. In the southeast, states have typically had alternative certification pathways and traditional pathways for teacher certification. Though the states have similar processes, they have different guidelines and restrictions with regard to certification (Georgia Department of Education [GDOE], 2015; Tennessee Department of Education [TDOE], 2015; Mississippi Department of Education [MDOE], 2015; South Carolina Department of Education [SCDOE], 2016).

In the southeast region: Tennessee, Georgia, South Carolina, and Mississippi all have options leading to certification that include a traditional route through education coursework including a bachelor's degree in education, and an alternative certification route with a bachelor's degree in a content area other than education. The states have science certification at various levels, but each state has the categories of science certification separated differently. Tennessee has the least amount of specific oversight, and Mississippi has the most specifications related to the teacher certification process (GDOE, 2015; TDOE, 2015; MDOE, 2015; SCDOE, 2016).

In Georgia, teachers are required to have a bachelor's degree. To become a teacher, a student can earn a bachelor's degree that includes foundational knowledge, skills, pedagogy, and an internship. A person can receive an alternative certification in a different field, and then complete the teacher preparation coursework while teaching. Teachers with alternative certifications can complete the teacher preparation courses work in a year's time, and they are required to take basic skills assessments that "measures teaching candidates' knowledge and skill in relation to reading, writing and mathematics" (GDOE, 2015, p 1). The second assessment measures the content knowledge in the candidate's chosen field. Georgia has an application process whereby teaching candidates supply their information and a small fee for licensing.

Georgia science certifications are middle grade science, Biology, Chemistry, Physics and Earth/Space Science. The science certifications for teaching are added using the traditional certification route or the alternative certification route (GDOE, 2015).

Tennessee has a procedure similar to that of Georgia. Candidates are licensed if they are enrolled or have completed an educator program that has been approved by the Tennessee Department of Education. Tennessee has a series of assessments that the candidate must pass to receive a license to teach. Tennessee certifications of science are separated by grade levels as follows: (a) middle science 6-8, (b) Earth Space Science 6-12, (c) Earth Space Science 7-12, (d) Biology 6-12, (e) Biology 7-12, (f) Chemistry 6-12, (g) Chemistry 7-12, (h) Physics 6-12 and (i) Physics 7-12 (TDOE, 2015).

Mississippi has a multi-tiered traditional and alternative certification process. Two forms of licensure are available: a one-year intern license and a five-year educator license for traditional teacher candidates. For alternative certification, Mississippi offers three different three-year licenses, each having a specific group of tests and educator program to attend, plus a five-year alternative certification license. For the alternative certification licenses, the content areas available are: art, biology, business, chemistry, Chinese, economics, English, French, German, health, home economics, Latin, library media, marketing, math, physics, physical education, social studies, speech communication, and special education. Mississippi requires very specific programs to complete the teacher education process for alternative certification, plus assessments in content areas. Mississippi’s science certifications are Biology 7-12, Chemistry 7-12, and Physics 7-12 (MDOE, 2015).

South Carolina has both traditional and alternative certification routes for teacher candidates. Traditional teacher candidates must submit college transcripts, submit passing assessments scores for general and content area assessments and pay a small fee. Alternative candidates must choose a specific pathway, similar to Mississippi's, for alternative certification. Teaching candidates can choose a program for alternative certification to meet the education requirement after attaining a bachelor's degree in a specific subject. They can participate in the Teach for America program, or can participate in the American Board for Certification of Teacher Excellence. South Carolina includes the science teacher certifications of Biology, Chemistry, Physics, middle level science, and science (SCDOE, 2016). Each state is allowed to specify the requirements for teacher certifications. The certifications determine which subject areas the teachers are allowed to teach and at what grade level.

Professional Development

Components of Effective Professional Development

Professional development has been designed to help teachers improve teaching skills to help improve student achievement regardless of background certification and to help teachers learn new strategies to become more effective. Educators believe that professional development can have a positive impact on student achievement, but this is difficult to track (Whitworth & Chiu, 2015). A teacher's background, beliefs and other characteristics are not considered in professional development opportunities and can cause the implementation process to stall out (Chval, Abell, & Pareja, 2008). There are characteristics that professional development should include; there are overarching groupings or professional development models based on presentation type; and there are a wide variety of types and different formats for professional development. Regardless of these variables, a key factor for professional development is how teachers respond to it and if they choose to make changes in their classrooms based on the knowledge and experience they have gained in the activity.

Whitworth and Chiu (2015) observed that professional development encourages teachers to be active learners, stating that professional development should include "active learning, a strong content focus, be coherent and of a significant duration" (p. 123). Continuous active learning occurs as teachers reflect on practice and are allowed to continually refine their learning experiences through classroom implementation. Teachers gain knowledge and apply a strategy learned into a classroom practice, and the process is repeated as new information is learned. Teachers' need for continuous learning comes from the expectation that teachers will continually need to readjust with changes that are occurring. According to Aseeri (2015), "changes that occur in curriculum, technology, communication, textbooks, and the latest findings in the field of educational research" (p. 87) require teachers to continually learn new information and skills. The new information in education must be presented, implemented, reflected on and evaluated for the continual learning process to occur (Aseeri, 2015). Other examples of active learning by teachers is an observation with feedback and discussion (Desimone, 2009) from administrators and peers to learn from and readjust if needed.

Jeanpierre, Oberhauser, and Freeman (2005) stressed the importance of the content learned in professional development for teacher growth and student achievement, noting that "choosing the content of professional development may be the most important decision when developing a professional development program" (p. 671). Whitworth and Chiu differentiated between pedagogical and professional development content, stating that pedagogical content can help teachers change practices in the classroom but that professional development in content improves teachers' content knowledge in areas of deficiency.

The coherence of professional development is determined by the alignment of the professional development to what the teacher is required to teach. Coherence in professional development is described as an "extent to which teacher learning is consistent with teachers' knowledge and belief" (Desimone, 2009, p. 184). Professional development can help teachers identify and work through any problems with implementation that occur once the teacher returns to the classroom. Ideally, teachers would receive feedback that was specific to their needs in their classroom to help with coherence of what was learned and how to implement it effectively (Whitworth & Chiu, 2015).

The amount of time spent in professional development also has an impact on implementation of the strategies learned in the professional development. The longer the professional development is, the more likely the educator will be to implement the strategies (Whitworth & Chiu, 2015). The relationship between the time in the professional development and the number of meetings to impact change has not been exactly defined (Desimone, 2009), but short, single day workshops have little impact on teacher implementation of the strategies taught in the professional development. It has been problematic that often times, districts have not had adequate funding to support long term professional development opportunities and have opted for short, single-day workshops (Chval et al., 2008).

Another component of professional development effectiveness is collective participation (e.g., multiple teachers from the same grade level at the same school being involved). Collective participation can increase the teacher discussion and implementation of the activity learned (Desimone, 2009). Learning communities are another example of professional development that offer teachers a place where they can learn and accept ideas from each other (Taranto, 2011). Professional learning community can provide a supportive structure for professional development opportunities.

In the past, those attempting to assess the value of professional development have largely tracked teacher attitudes and satisfaction toward professional development in workshops and conferences rather than the impact on student achievement. Teachers' learning, however, can take place through informal or formal professional development. Professional development now includes informal learning communities or action research projects. These type of professional development opportunities allow teachers to use the strategies in the classroom immediately (Desimone, 2009).

> Teachers experience effective professional development, the professional development increases teachers' knowledge and skills and/or changes their attitudes and beliefs, teachers use their new knowledge and skills, attitudes and beliefs to improve the content of their instruction or approach to pedagogy or both, and the instructional changes foster increased student learning. (Desimone, 2009, p. 184)

These critical features constitute the basic assumptions about how professional development will be used by teachers to improve instruction for students. Two major components of the critical features are the change in instruction and the change in attitude and beliefs of teachers. Outside factors that can impact the implementation of the critical features are student characteristics, teacher characteristics, factors in the classroom, school, school district, and school policy. According to Desimone (2009), these interactions determine how the models are implemented regardless of the model or grouping of the professional development.

The Design of Professional Development

Professional development is designed to align state and district standards to content, activities, and pedagogy (Chval et al., 2008). This design aligns with the professional development being coherent and including classroom strategies. Effective professional development helps improve teachers' instructional capacity, defined as "the capacity to produce worthwhile and substantial learning" (Carlisle, Cortina, & Katz, 2011, p. 213). These researchers reported that professional development models are often difficult to apply in a classroom. Though professional development is designed to be help teachers by improving their teaching and impacting student achievement, the new knowledge is often difficult for teachers to implement.

Koellner and Jacobs (2014) identified two approaches for professional development: highly specified and highly adaptive. A highly adaptive approach for professional development is "readily responsive or adaptive to the goals, resources, and circumstance of the local professional development context" (Koellner & Jacobs, 2014, p. 51). An example of a highly adaptive professional development would be a whole system model. This model assumes that everyone at the school needs to be involved with the professional development if the change is to be sustained. The model is adaptive with training happening at all levels simultaneously (Ferreira, Ryan, & Tilbury, 2007).

A highly specified approach to professional development would include goals, content and materials that are prescriptive and pre-determined (Koellner & Jacobs, 2014). An example of a highly specified approach to professional development would be the collaborative resource model. This model "assumes that change can occur through the provision of curriculum and pedagogical resources and adequate training in the use of these" (Ferreira et al., 2007, p. 229). There are professional developments that fall somewhere between highly adaptive and highly specified. Often, teachers are offered both types of professional development to help increase student achievement. Even though the goals are similar, the structures and implications vary (Koellner & Jacobs, 2014).

Pill (2005) defined four types of professional development that are the basis for most professional development opportunities available for teachers. The first, reflective practice, is based on the practice of teaching theories that teachers use daily. The professional development dealing with the theories teachers apply allows educators to reflect on the knowledge gained from the professional development and how they become a classroom practice. The emphasis of this type of professional development is internal change in teachers' beliefs and practices. This would be an example of an adaptive professional development.

Action research is another form of professional development where teachers can research and critically review their practice. Again, this model is adaptive and very dependent on teachers' individual research and theories (Pill, 2005).

The next model is the novice to expert approach to professional development. This model is a common design for professional development and is one of the highly specified approaches. The model suggests that teachers move from novice to expert teachers through a specified training in theory and learning through experience. Often, facilitators or other teachers help the novice teacher move toward becoming an expert, helping in the development of theory in practice (Pill, 2005).

The last model of professional development learning is metacognition which helps teachers "move from largely having implicit experimental knowledge to knowing what they do or, indeed, do not know" (Pill, 2005, p. 138). Once teacher realize their knowledge base, they can focus on a change in professional practice. These models for professional development can have an impact on teacher growth, helping them to implement new strategies in the classroom and have a positive impact on student achievement.

Borko's (2004) description of professional development design focuses on the key interactions of professional development are the interactions between facilitators, the professional development program, teachers and the context of the professional development. Borko's first type of professional development focuses on the facilitator at a single sight working with teacher as learners and their interaction with the professional development program. Evidence shows that this type of professional development can increase teachers' content knowledge and improve their teaching. A second type of professional development program includes multiple teachers and multiple facilitators at multiple sites, all interacting with a program. There is less research on the effectiveness of this type of professional development. Borko expressed the belief that the larger the professional development, the more difficult it is to determine the impact on student achievement.

Professional development has been central to the education reform process, and it is vital to help teachers continue to learn while being in the classroom. A challenge of professional development is the understanding of teacher learning and how the learning impacts the classroom (Lewis, Baker, & Helding, 2015). The impact professional development has on teacher change has be studied, but there is less research linking professional development directly with improved student achievement (Whitworth & Chiu, 2015). Teachers may encounter barriers and support, depending on administrators, students, and other teachers. If there are barriers to implementation of the information learned in the professional development and it is not supported and encouraged, the teacher may not implement it. This could hinder student achievement over time. It is difficult to fully understand the impact of professional development and how it translates into success in the classroom (Lewis et al., 2015).

Teacher change after attending a professional development opportunity is a factor the has an overall impact on student achievement. Outside factors that impact teacher change are teacher experience, motivation, and self-efficacy. Teachers with more experience are more likely to change their practices inside the classroom and focus on learning advanced content and pedagogical content knowledge. Teachers may be motivated to attend a professional development to gain new knowledge or to gain a higher position. It is these factors that will motivate teachers to change their practice. Teachers with higher self-efficacy are more likely to change due to attending a professional development opportunity (Whitworth & Chiu, 2015).

Professional development in science has critical features of providing "teachers opportunities for collaborating within a community of peers. Furthermore, it is critical that teachers gain enhanced understanding of content and pedagogy as they undergo a transformative experience" (Kazempour & Amirshokoohi, 2014, p. 286). Professional development in science started with content knowledge professional development occurring in isolation from pedagogy professional development. For science professional development to be effective, professional development needs to integrate learning science content with learning science pedagogy, especially inquiry skills (Jeanpierre et al., 2005). In recent years, "professional development has been more broadly used and diversified, creating a myriad of options through which teachers improve their science content knowledge, methods for engaging students, familiarity with exciting curricula, and knowledge of how to conduct scientific research" (Lewis et al., 2015, p. 897). This is an attempt to help professional development help teachers engage in the information using andragogic learning.

Professional development that focuses on induction-year teachers is the first interaction most teachers have with professional development. Induction-year professional development has seven features for a professional development to be meaningful for first-year teachers. They are: (a) being driven by a clear image of effective classroom learning and teaching, (b)help teachers build knowledge and skills, (c) use models that teachers can use with students, (d) form a learning community, (e) help teachers move into leadership roles, (f) help build bridges to other parts of education, (g) allow self-reflection and assessment (Rodriguez, 2010). The induction teachers need to understand the overall purpose of the professional development, and their professional development should be situated and meaningful to their daily challenges. They should be in a work context that is aligned with the daily practice advocated in the professional development (Trumper & Eldar, 2014).

Pre-service and Induction Professional Development

"The shortage of teachers in the United States is a continual and growing problem" (Harvey & Gimbert, 2007, p. 42). The traditional route of pre-service teachers earning a bachelor's degree in education is not likely to solve the teacher shortage problem which has been compounded by 29% of teachers leaving the profession after the first three years (Harvey & Gimbert, 2007). Pre-service teachers are those students who move through a traditional route toward certification as they complete university education programs that vary in quality. Alternative routes of certification, which were implemented to help with teacher shortages and help content experts become teachers, require education course work while teaching (Harvey & Gimbert, 2007). These systems contribute to a variance in teacher quality (Kind, 2015). States often have both types of certification options, and teacher candidates with either of these certification types can apply for teaching positions.

The quality of the teacher and the quality of the certification impacts the students because the quality of teacher is the most critical factor in educational achievement (Kind, 2015). Luke and McArdle (2009) identified contributing factors to teacher quality as: high quality applicants, high level degrees, high level content knowledge, participation in curriculum development at the local level, and professional development opportunities (Luke & McArdle, 2009).

Pre-service teaching candidates and alternative certification teaching candidates face stressors when beginning their careers as novice teachers. Being a new teacher can cause anxiety, and new teachers need to practice pedagogy, learn teaching cultures, and establish a professional reputation (Fresko, 2014). Professional development, beginning with induction programs and continuing throughout a teaching career, is a main form of continuing education that allows teachers to communicate with other professionals, learn pedagogical strategies, and improve content knowledge (Bang, 2013).

LoCascio, Smeaton, and Waters (2016) observed that once teacher candidates become teachers, it takes three to five years for them to build confidence and “skills to manage a classroom effectively, prepare lessons that engage students learning meaningful content, and build assessments that challenge students and provide accurate data about learning" (p. 104). Professional development is the mechanism that helps teachers to learn the skills needed to build confidence.

Induction trainings are professional development programs for first-year teachers that focus on instructional techniques and pedagogy to help students succeed (Cherubini, 2007). Effective induction programs are continuous and connected to student learning (Bang, 2013). The quality of the induction program impacts teacher attrition (Cherubini, 2007), and because of this, administrators need to involved in the process. An administrator's focus on in-service induction programs can significantly improve a first-year teacher's retention and growth in educational practices (Brock & Grady, 1996). I n urban districts, administrators have the added responsibility of assisting induction teachers as they learn the culture of the school and the community and help new teachers deal with the possible culture shock of the school (Duncan, 2014).

To be effective, induction programs should include a context for the first-year teacher to grow and construct new information and experiences from the classroom. Through induction programs, new teachers are given an opportunity to learn the interactions within the school and be part of a learning community. They learn what the expectation is for teaching and what is considered a quality learning situation for students. They learn how to create learning environments for students (Haggarty, Postlethwaite, Diment, & Ellins, 2011). Beginning teachers who participate in induction programs that enrich their current teaching abilities and understanding will be more likely to be active learners throughout their teaching careers (Luft et al., 2011).

Induction year professional development for first-year science teachers is specifically needed. Often times induction training includes topics such as lesson planning, organizing classrooms and classroom management. First-year science teachers need training in practical topics like organizing labs and in pedagogical training in inquiry and classroom management (Luft et al., 2011).

For first-year science teachers, regardless of alternative or traditional certification, there are specific areas of professional development that are needed. They need content and curriculum knowledge to plan instruction and help with student interaction (Luft, Duboi, Nixon, & Campbell, 2015). They need to know the science concepts and develop a deep understanding of the science discipline they are teaching. First-year teachers need training in pedagogical content knowledge and how curriculum plays a role in pedagogy (Luft et al., 2015). Professional development can be used effectively to help teachers learn the skills they lack due to variance in educational background.

First-year science teachers need to learn how to transfer their science content knowledge and science inquiry skills to students on a consistent basis. They especially struggle with transferring nature of science, or science skills to students even when they understand the process of learning science. First-year science teachers may encounter barriers to beginning the inquiry process. here are multiple barriers to teachers implementing inquiry such as lack of support by colleges and administrators, lack of pedagogical knowledge and content knowledge, and lack of experience (Nam, Seung, & ManSuk, 2014). First-year science teachers need to learn how to make the classroom a student-centered rather than a teacher-centered environment (Luft et al., 2015). Luft et al. (2011) studied beginning science teachers' growth in pedagogical content knowledge with ongoing induction support. Beginning teachers are "learning to teach, or engaging in professional development programs, they are building pedagogical content knowledge (PCK) that will support new way of learning in their classrooms" (Luft et al., 2011, p. 1202). The extra support of an induction program allows beginning teachers to build their pedagogical content knowledge.

One example of pedagogical content knowledge is inquiry. Inquiry has been described as developing a classroom where students generate questions, investigate hypotheses, gather data, and communicate results (Luft et al., 2011). Induction science teachers' belief about inquiry is the most critical determinant to whether they will practice inquiry in their classrooms (Ozel & Luft, 2013). Beginning teachers without inquiry experience may have limited conceptualization of inquiry, and do not expand the conception over time (Ozel & Luft, 2013).

Outside of the need for professional development in science skills, specific science professional development opportunities are needed to help teachers learn how to differentiate instruction and create a student centered environment for equity of access in the science classroom (Bianchini & Brenner, 2009). First year science teachers struggle with providing equity in education to all students. Students who are homeless, English language learners, and lower socio economic students represent a population of students that first year science teachers may find difficult to teach. To help beginning teachers create equity in their classroom, induction models that include teachers learning from a professional learning community and from students need to be developed (Bianchini & Cavazon, 2006).

Induction programs are designed as an initial professional development to help teachers regardless of background certification. The professional development is specific to first-year teachers learning the skills needed to help students be successful. Professional development for science teachers has primarily been designed to provide an opportunity for science teachers to increase content knowledge and/or pedagogical knowledge in a specific area. There has been, however, a new focus on improving the rigor in professional development and investigating how teachers implement the professional development (Lewis et al., 2015).

Conceptual Framework

Professional development for educators has been used to help teachers to continue to learn as they teach. It has been defined as “those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students” (Eun, 2008, p. 134). Professional development for science teachers has been framed in three theoretical frameworks: social constructivism, constructivism and andragogy. These frameworks, which help teachers learn, retain, and use the content of professional development, comprised the conceptual framework for this research and are discussed in the following sections.

Social Constructivism

As a proponent of social constructivism, Vygotsky interpreted learning as social and culturally based, not based on an individual’s independent cognition (Eun, 2008). Vygotsky believed that human interaction was the way humans develop a sense of reality (Eun, 2008). Vygotsky explained the mechanisms of development through social interaction as mediation.

Mediation, according to Eun (2008) was divided into three categories: "mediation through material tools, mediation through symbolic systems, and mediation through another human being" (p. 137), and humans learn by adapting material tools or the equipment needed for the development to occur (Nattall, 2013). The symbolic system is the actual skills needed for the development or learning to occur. The other human being is the person who is more competent to help with the development process. For Vygotsky's theory of social constructivism, persons learn and internalize a piece of knowledge through the interaction with someone more skilled or competent than themselves (Eun, 2011).

Eun (2008) saw Vygotsky's theory as different than other social learning theories because of the depth of the social interaction's importance in development and learning and "Vygotsky's insistence on viewing behavior and mind or social interaction and consciousness as aspects of a single system" (p. 138). The social interaction becomes the learned behavior through the mechanisms' interactions. The learning is not instantaneous or automatic, and the key is the internalization of the social interaction. For the social interaction to help with an individual's development, there must be a clear goal or purpose to the activity (Eun, 2008).

Vygotsky's social constructivism theory includes the zone of proximal development which has been defined as the "distance between actual development as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 76). In terms of science professional development, the teacher moves from being a consumer of information to a participant and a producer. The change occurs because of the interaction and construction of information through collaboration (Torres, 1996). There are different types of professional development that align with Vygotsky's theory: training, mentor/mentee, study groups, and inquiry type professional development and professional learning communities.

Vygotsky's zone of proximal development can help experienced teachers mentor novice teachers on particular topics (Lewis et al., 2015). Mentoring can be accomplished through an internship with pre-service teachers, with induction-year teachers, or with struggling in-service teachers. Mentoring can bridge "both individual cognitive processes and group social practices, allowing researchers to capture the complexity of the phenomenon of teacher change" (Lewis et al., 2015, p. 902). Both teachers learn because both will move into their zones of proximal development.

Professional development for educators aligns with Vygotsky's theory of development because social interactions play a key role in individuals learning a subject. Professional development programs are led by individuals who are trained facilitators and allows for teachers to interact during the learning process (Eun, 2008).

Professional development that includes mentors work within Vygotsky's theory of the zone of proximal development. The mentor and the mentee both have learning experiences for their interactions. The interaction between the mentor and mentee will help both grow in their learning (Eun, 2008).

Study groups or inquiry type professional development help educator learn through engagement with other teachers. The study group or inquiry type of learning is typically goal oriented. Often times, there is goal or a problem to be solved for a specific reason. Teacher interaction will increase when teachers are allowed to help set the learning goals in the professional development (Eun, 2008) or when they participate in a professional learning community.

A professional learning community "embraces the social nature origin of individual development while recognizing the importance of continuous, ongoing school-based collaborations among all the members of teaching and learning process based on a common goal" (Eun, 2008, p. 146). Professional learning communities allow for collaboration of teachers in implementing professional development and reflecting with others as they experience and observe the internalization of the professional development. The internalization and learning from the professional development will occur after the interaction with others (Eun, 2008). A teacher needs time to internalize and to use the skills and knowledge gained. Teachers need time for reflection and implementation as well as continual support. Ideally, through social interactions, they will continue to move through the zone of proximal development (Eun, 2008).

Educators need time to internalize the professional development using Vygotsky's theories. The internalization process occurs through small steps of learning and implementing changes in the classroom. Teachers may also regress before moving forward in learning. Teachers need time to reflect after implementing the strategies learned, according the Vygotsky. The continual time and support with help teachers move through the zone of proximal development (Eun, 2008)

Constructivism

Piaget's cognitive constructivism is knowledge created by individuals constructing "new knowledge from their prior experiences through the processes of assimilation and accommodation" (Wang & Ha, 2011, p. 265). Constructivism is based on the philosophy of science and has root in the philosophical ideas of ontology and epistemology (Oxford, 1997). "Ontology refers to issues concerning the nature of being" (Oxford, 1997, p. 37), and tries to answer the question, "What is reality?" Epistemology tries to understand the basis of knowledge, and tries to answer the question, "What is knowledge?" Piaget's ideas on how children learn were based on biological and cognitive development through organization and adaptation with the environment. After Piaget introduced his theory, many others modified it into different types of constructivism, from radical to social.

Constructivism theory is based on how human learn new information. "Constructivism is generally the approach that learners construct their own knowledge from interpreting their experiences" (Doolittle, 2014, p. 486). A learner has an experience or an event, and through a process of assimilation reorganizes the information to understand the new experience or event. The learning process is the experience and the re-organization of the information (Doolittle, 2014). Constructivism teaches critical thinking skills and develops active learners (Beamer, Van Sickle, Harrison, & Temple, 2008). "Cognitive development is a result of invariant changes in internal mental structures, characterized by a continuum of different reasoning skills, and caused by integrating and extending previous levels of cognitive development into new knowledge/cognitive levels" (Doolittle, 2014, p. 487). The environment impacts the learner, who is gathering knowledge from the interaction with the environment (Juvova, Chudy, Neumeister, Plischke, & Kvintova, 2015).

Constructivism is a learning theory that can often be mistaken for a curriculum design. The holistic aspect of constructivism allows for learning to occur in the correct context of the content area (Doolittle, 2014). There are certain beliefs that a constructivist teacher should have.

First, students may not progress toward the expected goals in a uniform manner, and some may not achieve the goals. Second, teachers must understand there are many paths to learning and understanding information. Third, students have different understandings of topics. Fourth, students have different levels of understanding, and they do not understand all the content all at once and completely (Oxford, 1997).

Constructivist teaching is designed to create the opportunity for students to learn. To construct new information, learners take into consideration the prior knowledge they have about a topic. This is one of the key components to constructivism: the learner must elicit prior knowledge to experience a cognitive dissonance with any new information (Baviskar, Hartle, & Whitney, 2009). The learner must apply the knowledge with feedback from a teacher or facilitator. The facilitator is a guide in learning, helping the learner apply new information, rather than a direct instructor (Juvova et al., 2015). Finally, the learner must have time to reflect on learning (Baviskar et al., 2009). Reflection on the information occurs when new information is assimilated with the prior knowledge to form a new concept or new content.

When constructivism principles are used in a classroom, the students become active in the learning process and self-manage their learning. Applying constructivism in a classroom helps to motivate students to learn the information, with the teacher acting as a guide or facilitator. The students learn problem-solving skills and how content is interconnected. Constructivism principles allow students to learn through the action learning process and allows students to learn through failure (Juvova et al., 2015)

Beamer et al. (2008) adopted constructivism as the basis for a science classroom using the following criteria: “(1) personal relevance, (2) scientific uncertainty, (3) critical voice, (4) shared control, and (5) student negotiation" (Beamer et al., 2008, p. 49). Personal relevance helps students to learn through questioning the environment, activating the prior knowledge needed for learning (Beamer et al., 2008). Science uncertainty is described as knowledge that is gained based on a scientific theory, but there is an uncertainty that is understood and examined. In constructivism, there is cognitive dissonance that has to occur. Critical voice is described as an opportunity for learners to question the information being presented, and this allows learners to ask information from the teacher to help in the assimilation process. Students feel comfortable to voice the dissonance they are experiencing (Beamer et al., 2008). Shared control in a learning environment represents a learner centered environment as opposed to a teacher centered environment. The student negotiation aspect of a learning environment allows for learners to share, describe, and justify their new ideas. Each aspect of the learning environment allows learners, teachers, or students to have an active role in their learning (Beamer et al., 2008).

Constructivism combines individual ownership and a holistic approach to science education reform (Doolittle, 2014). Constructivism is the foundation of a reform movement in science education (Trumper & Eldar, 2014). The model of constructivism in the science classroom is a foundation for inquiry students or learners to use to construct science content. Constructivism helps students learn content through science process skills (Trumper & Eldar, 2014).

In a constructivist environment, the curriculum is presented in its entirety to emphasize a concept. Students are encouraged to ask questions, use primary data and manipulatives to learn content and interact with participants. Assessment of learning is interwoven with learning (Haney & McArthur, 2001). Educators who actively structure their classroom experiences to help students construct new ideas create ways to better see the teaching and learning relationship among learners and teachers (Loughran, 2013). Professional development with a constructivism focus uses methods such as open-inquiry, guided inquiry and problem-based methods for teachers to learn and construct new information (Khourey-Bowers & Fenk, 2009). Modeling, coupled with other learning techniques, can improve the cognitive constructivism process for teachers learning new strategies (Khourey-Bowers & Fenk, 2009).

Educators have different views and levels of understanding regarding constructivism and how it applies to a classroom. Mathematics and science teachers often categorize themselves as explicit, or more traditional teachers, and traditional teachers see their role as transmitting knowledge to students (Arce, Bodner, & Hutchinson, 2014). Professional development can help mathematics and science teachers increase their own inquiry type thinking that will help in implementation in the classroom (Snider, 2007). Constructivism professional development for science teachers often focuses on science content knowledge, pedagogical content knowledge, and a specific type of pedagogical content knowledge described as inquiry learning. Constructivist professional development is explicit, (i.e., the focus of the entire professional development), or implicit, (i.e., teachers learning content through inquiry).

Andragogy

Andragogy is a theory on how adults learn (Ntombel, 2015). Andragogy differs from pedagogy due to adults learning differently than children, so different strategies need to be applied for learning to take place. Andragogy "emphasizes that adults are self-directed and expect to take responsibility for decisions" (Osman, 2014, p. 76). Adults often learn in informal settings where there is a facilitator instead of a teacher to help learning take place. There are five main assumptions when helping adults learn: (a) adults no longer need to depend on someone else to set goals in learning, (b) adults have experiences to help as a learning resource, (c) adults are ready to learn, (d) adults learn as a way to apply information to solve problems, and (e) adults are intrinsically motivated to learn (Ntombel, 2015). Assumptions to adult learning are that adults need to think that the information they are learning is important, and they need to learn in an experimental, problem solving environment (Osman, 2014).

The first characteristic of adult learners is a desire to learn which is “motivated by what is relevant to their respective contexts” (Elliot & Campbell, 2015, p. 383). They are often intrinsically motivated instead of extrinsically motivated. Factors that motivate adults to learn are often increased self-esteem and quality of life (Cercone, 2008).

The second characteristic of adult learners is self-direction—adults who are learning are typically self-reflecting and self-leaders (Elliot & Campbell, 2015). Adult learners should be independent and motivated to reach their goals for learning. They are “autonomous, independent, and self-reliant” (Cercone, 2008, p. 143) and want to learn specific information that is meaningful to them.

The third characteristic of adult learners is that they have prior experiences that can help in generating “new ideas and skills, and enabling construction of further knowledge” (Elliot & Campbell, 2015, p. 384). Similar to constructivism, andragogy focuses on learning from prior knowledge and experiences (Cercone, 2008), and learners attach new information beig learned to prior information.

The fourth characteristic of adult learners is a readiness to learn. Adults often need to learn to deal with “changing social roles and job responsibilities” (Elliot & Campbell, 2015, p.

384). This ties into the characteristic that adult learners are also goal oriented and know what they want to learn and have a goal to learn it (Cercone, 2008).

The last characteristic of adult learners is the purpose of learning. Adults often have a problem to solve that drives their desire to learn (Elliot & Campbell, 2015) and the information they learn will help them solve their problem (Cercone, 2008). They want to know how the information will be of benefit to them. They want to understand the usefulness of what they are learning before they begin and know that they will be able to immediately use their new knowledge (Elliot & Campbell, 2015). Adult learners are often more driven by practice and to use what is useful rather than the theory behind the learning.

Andragogy makes assumptions about adult learners that may not entirely hold true in every adult learning situation. Teachers who had "traditional, formal schooling backgrounds may be less independent as learners simply because traditional schooling methods have tended to place students in passive roles" (Henning, 2012, p. 11). Some adults may need more structure in the beginning to help them move toward being more independent and self-directed in learning (Cercone, 2008).

Another assumption about adult learning is the basis on prior knowledge. In some cases, adults may have very little prior knowledge to build on a topic, and this may complicate the learning process. For example, professional development dealing with technology may be more difficult for teachers who have little experience with technology (Henning, 2012).

Researchers have expanded on the original theory of andragogy. Adult learning, through experience and building on prior learning, has given rise to the idea of experiential learning or building experiences by interaction, reflection, and application of the new knowledge or skills

(Henning, 2012). This is an example of social constructivism being used in an adult learning strategy. Other expansions to adult learning theory are self-directed learning and transformative learning. “Self-directed learning puts the learner in control of his or her learning” (Henning, 2012, p. 12). The self-directed learner sets goals, and learns in formal and informal environments. Transformative learning, according to Henning (2012) deals with individuals changing their views about how they perceive the world, (i.e., making a paradigm shift). The three expansions of adult learning are part of the structure of professional development and the changes that need to be made for professional development to be effective and impact student achievement.

Educators use informal andragogic skills to decide what skills are needed to teach the students appropriately. A teacher has to acquire knowledge and information about the students to teach the students effectively. Teachers are required to learn the skills needed, which often happens in an informal setting. Teachers who lack certain competences are normally aware of the deficiency and actively seek learning opportunities (Nurhayati, 2015).

The principles of andragogy are helpful when designing a professional development because it takes into consideration the aspect of how adults learn. Andragogy takes into consideration that adults learn differently and think about learning differently than children. Adult learners know what their learning needs are and can form learning objectives based on their needs. They can gather the resources needed to learn and evaluate the learning process (Elliot & Campbell, 2015). Examples of strategies that could be used in professional development for teachers could be case studies, simulations, and self-evaluation (Osman, 2014).

Professional development based on andragogic principles must consider adults' prior learning (Cercone, 2008). A professional development facilitator would need to gather the information about prior knowledge to help participants relate the information they are learning to prior knowledge (Cercone, 2008).

Professional development needs to have goals that are clear and aligned, so participants understand what the goals of the program are and how they align to their own goals. This follows the principle that adult learners are goal oriented and relevancy oriented. It is important to adults to learn information that can be applied immediately (Cercone, 2008). Professional development for adults should focus on participants' reflections on what they have learned and how it will be used. The facilitator should allow students to reflect on their learning to decide how the information can be applied and how it helped in meeting their goals (Cercone, 2008).

In their discussion of characteristics of professional development that were tailored to with an adult learning model, Elliot and Campbell (2015) noted that teachers attending professional development want strategies that are helpful and task-centered. Zepeda, Parylo, & Bengston (2013) added that the tie between andragogy and professional development was the learner being self-directed and reflective (Zepeda et al., 2013). Adults may want to direct their own learning in a professional development opportunity with facilitators guiding the learning process but leaving the goals of what is learned to the participants (Cercone, 2008). To be effective in learning, adults need to take ownership of the information, find it appropriate, and have an opportunity to collaborate and reflect on the material (Zepeda et al., 2013). Adult learners need to have ownership in the process for learning to take place and then be given time to collaborate with others and reflect on the learning. This is vital to professional development strategies being used in a classroom to impact student achievement.

In summary, professional development should be designed to meet teachers' needs and be able to be implemented immediately in classrooms. Teachers, self-motivated for learning, use prior experiences in the classroom to generate new ideas with other teachers (Elliot & Campbell, 2015).

Pedagogy Content Knowledge

Pedagogy is a teacher's method of engaging the learner about the topic in a classroom; thus, pedagogy focuses on the relationship between the teacher and the learner (Loughran, 2013). Pedagogy deals with a teacher's active decision making about the learner and the subject and how the subject matter should be taught. Pedagogy is "how teachers' actions and intentions were understood and interpreted by students" (Loughran, 2013, p. 121).

"Pedagogy content knowledge is the knowledge of representations, analogies, and strategies useful for teaching a particular topic as well as knowledge of students' ideas about that topic" (Santau, Maerten-Rivera, Bovis, & Orend, 2014, p. 957). According to Luft et al. (2011), pedagogical content knowledge is the knowledge of how to teach content effectively so students will learn the material. This type of knowledge is integrated into how teachers work with students in the classroom (Luft et al., 2011). Pedagogical content knowledge are the strategies teachers use, (e.g., demonstrations or illustrations), to help students comprehend the material (Loughran, 2013). A teacher's knowledge about how to teach a subject effectively shows the quality of the teacher. The more effective the strategies, the higher the student achievement is likely to be (Kind, 2015). Pedagogical content knowledge is described as the specific knowledge teachers have to effectively teach a specific topic so students can comprehend it (Lakin & Wallace, 2015).

Pedagogical content knowledge components mesh in a classroom. Content knowledge, student relationships, assessments and teaching beliefs all work together to determine how a teacher will teach a subject. Williams, Eames, Hume, and Lockley (2012) identified five different components of pedagogical content knowledge: "orientations toward teaching, knowledge of curriculum, knowledge of assessment, knowledge of students understanding of the subject, and knowledge of instructional strategies" (p. 328). Teachers over time acquire these skills.

There are various factors that contribute to a science teacher's pedagogical content knowledge. Science teacher orientation is a component of pedagogical content knowledge. Science teaching orientation is "knowledge and beliefs about the purposes and goals for teaching science to a specific age group" (Kind, 2015, p. 123). A part of the science teaching orientation is the nature, the teaching, and learning of science. There is variance in what teachers believe about teaching science, and their actual practice. An example of pedagogical content knowledge is a transformative model that "suggests that specific content knowledge being taught will be understood by students in ways that allow them to apply it in different contexts and different situations in a scientifically correct manner" (Loughran, 2013, p.125). Pedagogical content knowledge that is inquiry based would be teachers determining how a student could learn content through different inquiry methods (Santau et al., 2014).

Inquiry

Inquiry is a form of pedagogical content knowledge that science teachers use to teach concepts. Inquiry was originally developed so students might "have opportunities to learn how scientific knowledge is generated and to participate in the practice of science" (Lakin & Wallace, 2015). In science education, inquiry is a specific type of pedagogical content knowledge that is based on constructivism learning principals. Traditional science classrooms in which students have not been given the opportunity to construct new information have limited learning (Lakin & Wallace, 2015). There is no one standard inquiry method for science content. Inquiry methods for learning content try to help the student use the nature of science skills in a manner similar to how scientists work. Inquiry is the process to help students begin to learn science content in a setting similar to that of scientists who investigate science phenomena (Lakin & Wallace, 2015).

There are two types of inquiry professional development for science teachers. First, the teacher could attend a professional development where the content is taught using the inquiry method. In a professional development setting, teachers learn science by doing science (Greene, Lubin, Slater, & Walden, 2013). Inquiry is used to build teacher content knowledge. For teachers to implement inquiry, they need to "be familiar with both the nature of scientific inquiry and inquiry-based learning and implement such practices in their classrooms" (Kazempour & Amirshokoohi, 2014, p. 286).

The second type of inquiry professional development for inquiry is an explicit teaching of inquiry and how to use it in the classroom. "Inquiry-based professional development (PD) is a significant tool in facilitating science teachers' adoption and implementation of inquiry based planning, assessment, and instructional beliefs and practices" (Kazempour & Amirshokoohi, 2014, p. 286). In inquiry-based professional development, teachers learn how to implement inquiry in the classroom environment. Teachers have the opportunity to be involved in an authentic science research process (Peters-Burton et al., 2015), and they can apply the professional development strategies learned in a classroom to engage students. The students ask questions, propose hypotheses, do experiments and investigations, and produce explanations based on the evidence they gathered (Lakin & Wallace, 2015).

Inquiry professional development allows teachers to demonstrate the inquiry process to learn new information (Arce et al., 2014). The most important factor for sustaining inquiry based practices after professional development are:

> the duration of the professional development activity and the continuance of follow-up support, an increase in the teachers' science process skill and content knowledge, administrative support, allowing teacher a role in creating the curriculum materials, implementing professional development activities directly in the classroom context, and establishment of collaborative professional development community. (Lakin & Wallace, 2015, p. 140)

Even with a large amount of training, pre-service and in-service teachers have misconceptions about inquiry based teaching. Teachers' ideas of inquiry are often very broad (Lakin & Wallace, 2015). Those who did not learn through an inquiry process may well be uncomfortable learning through the inquiry process (Morrison, 2014). There have been five constraints that have been identified to stop teacher implementation of inquiry: "understanding of inquiry and the nature of science, strength of content knowledge, pedagogical content knowledge, beliefs about teaching in general, and management and student concerns" (Morrison, 2014, p. 795). Teachers need extra support in overcoming these barriers and developing an increased comfort level in implementing inquiry in their classrooms.

Teachers who use inquiry in their classrooms express that students should be actively involved in the learning process by questioning during the learning process to help guide student thinking. Students need to use science discourse in the inquiry process, communicating new information to peers to help with conceptual understanding (Lewis et al., 2015). Students in an inquiry classroom should be encouraged to construct scientific information using evidence and not simply performing verification labs (Morrison, 2014). “They expressed the belief that ‘best practices’ for classroom teaching would involve hands-on activities by students working in groups, leaving questions unanswered with the intention that students would be sufficiently motivated to keep experimenting and reach their own conclusions” (Arce et al., 2014, p. 92). Inquiry instruction increases the critical reasoning skills when learning the science content (Peters-Burton et al., 2015). The goal of inquiry learning in a science education is for students to construct science knowledge along with learning the skills of science and the scientific investigation process.

The learners in the inquiry environment are required to use scientific reasoning and critical thinking skills to develop an understanding of the content. They must also learn decision making when practicing inquiry. They learn to answer questions such as: “What counts? What data do we keep? What data do we discard? Are these patterns appropriate for this inquiry? What explanations account for the patterns? Is one explanation better than another?” (Banerjee, 2010, p. 2). Students need to learn to navigate through inquiry with a teacher who can facilitate the learning process (Bartolini, Worth, & LaConte, 2014). Professional development helps teachers implement inquiry in their classrooms and use inquiry as a pedagogic tool to teach science content.

Science Content Knowledge

Science content knowledge is the science content that a person knows and understands. Science content knowledge varies among science educators depending on prior education. Professional development for science content knowledge can help teachers bridge the gap in their science content knowledge. The study of the effectiveness of science content professional development has been focused on preservice teachers more than practicing teachers (Diamond et al., 2014).

Teachers' science content knowledge has a direct impact on science achievement, and the variances in science achievement have been largely attributed to differences in teacher qualifications (Diamond et al., 2014). The assumption is that science teachers have an understanding of the information they teach (McConnell, Parker, & Eberhardt, 2013). The tasks being referenced are not only teaching the content, but identifying student misconceptions, understanding of the models used to teach the content effectively, and help student engage in inquiry activities to construct learning (McConnell et al., 2013). The number of science courses a science teacher took in college has been shown to have an impact on student achievement along with teaching experience and the highest degree a teacher has earned (Diamond et al., 2014). Teachers teaching in and outside of their content field also have an impact on student achievement. A science teacher who is certified in physics and took multiple physics classes in college, is likely to have a negative impact on students if assigned to teach biology.

Teachers with strong content knowledge are also able to help students construct content knowledge based on previous information, questions students with depth of knowledge, and suggest alternative explanations for the content. Teachers with deep content knowledge understand how to address student misconceptions in science and help in the construction of accurate knowledge by students. They are able to create meaningful curriculum with multiple sources of information that address student needs (McConnell et al., 2013).

Teachers with low science content knowledge struggle in a science classroom (McConnell et al., 2013). A teacher's content knowledge can impact the type and depth of questions a teacher will ask in a classroom. Teachers with low content knowledge will ask low cognitive questions (Santau et al., 2014), and they may avoid teaching certain content areas that they do not understand or have a negative attitude toward that content area (Pecore, Kirchgessner, & Carruth, 2013). This can lead to science teachers using a more explicit or traditional type teaching method and not allowing students to construct new ideas using inquiry (Jeanpierre et al., 2005). Teachers with a low science content knowledge also try to avoid student questioning and discussions.

Elementary teachers often lack science content knowledge. Pre-service elementary education classes provide a generalist perspective and do not specialize in science (Santau et al., 2014), and elementary teachers may complete their education with a low science content knowledge. Because of this, they may spend less time on science in the classroom, creating a gap in student conceptual understanding in the advanced classes (Santau et al., 2014). The lack of science content knowledge has an impact on a teacher's pedagogical content knowledge. The teacher lacking in content knowledge will be unsure how to teach the content well pedagogically.

Professional development has been designed to help teachers learn science content in a similar manner as scientists learn science content (Greene et al., 2013). "Teachers need to have a deep and complex understanding of science concepts, and the ability to make connections among science concepts and apply them in explaining natural phenomena or real world situations" (Trumper & Eldar, 2014, p. 828). To learn science content knowledge in a professional development setting, the science content needs to be integrated with science processes. The skills scientists use in research are the skills science teachers need to use to learn content and teach content in the classroom. A teacher who is more comfortable with the content will be able to use pedagogical content knowledge to teach the content (Trumper & Eldar, 2014).

Professional development in science content addresses teachers' science misconceptions. Science teachers may have misconceptions on scientific topics that differ from accepted science standpoints. The misconceptions might be the same as their students' misconceptions. Professional development needs to address science content that specifically addresses misconceptions that students are known to have (Murphy & Smith, 2012).

Professional development in science content knowledge is often delivered by experts in the content area available at a university (Desimone, Garet, Birman, Porter, & Yoon, 2003), or through other venues such as a zoo or science museum (Pecore et al., 2013). Teachers need opportunities to elaborate on the knowledge learned and time to organize the content in a meaningful way for the professional development in content to be effective (Lewis et al., 2015).

A concern with science professional development in science content knowledge is it is difficult to measure how the professional development impacted student achievement. The National Science Foundation designed an instrument to measure both teacher and student science content knowledge. The instrument was designed to measure student achievement, alleviating the reliance on standardized assessments to measure student content knowledge (Trygstad et al., 2014).

Science content knowledge and pedagogical content knowledge are tightly bound together. Often times in a professional development, they are taught together, building both content areas to improve student achievement (Jeanpierre et al., 2005).

Collaboration and Professional Learning Communities (PLCs)

"Teachers need supportive, collegial communities when inquiring into significant questions about subject matter, such as science and mathematics, as well into questions concerning learning and pedagogy" (Jeanpierre et al., 2005, p. 671). This is the basis for professional learning communities (PLCs). Professional development that introduces collaboration among colleagues is the professional learning community (PLC) model. The PLC model helps teachers collaborate to learn new teaching concepts and improve learning environments (Taranto, 2011). Kelly and Cherkowski (2015) studied the professional development of reading teachers in the process of learning how to collaborate in a PLC. The teachers at first were uncomfortable in the collaborative environment, but throughout the year they developed a "sense of interdependence" (Kelly & Cherkowski, 2015, p. 16). The increase in collaboration caused a change in teaching practices and, in turn, led to an increase in student achievement.

Professional learning communities, which focuses on teacher collaboration, is not a recent idea to school reform. Dewey understood that teachers' need the opportunity to reflect on their teaching. Vygotsky's theory of social constructivism led to the development of peer collaboration amongst teachers. “In schools, sense making amounts to learning in socially embedded processes” (Riveros, Newton, & Burgess, 2012, p. 205). The team teaching movement and the middle school movement both were based on teacher collaboration. A drawback of the past education reforms that included teacher collaboration was that the focus of the reforms was on student learning and not professional practice in education. The professional learning communities were based on researchers studying inter-personal relationships for professional learning and include examining student achievement and professional practice (Riveros, Newton, & Burgess, 2012).

The professional learning communities are not designed to change organizational structures of the school, but are designed to change the attitudes and practices of the teachers. The professional learning community promotes discourse between the teachers, which improves teacher involvement. The teacher involvement helps in increasing the teachers’ knowledge and over time improve the school. The context of practice and shared learning are key components in a professional learning community (Riveros et al., 2012).

Professional learning communities are developed in the context that professional learning happens in the professional communities’ interaction. The teachers learn new education practices and those practices can be taught to peers due to the relational nature of teaching. Professional learning communities are designed that interactions occur between educators without the individuals losing their identity when participating in the community. The loosely bound PLC environment gives flexibility to deal with unexpected events and can change depending on the focus in practice that leads to school improvement (Rivero et al., 2012).

Teacher learning that occurs in professional communities has been described as "situated and social" (Bianchini & Cavazon, 2006, p. 588). Teacher learning is derived from teachers' situations and their interactions in those situations as they acquire new knowledge and skills to become part of the community. From a social perspective, teachers take the prior knowledge and experiences to make sense of the social interactions at the school (Bianchini & Cavazon, 2006).

Professional development has changed from being passive to active and this has been attributed largely to the development of professional learning communities. Successful professional learning communities are comprised of individuals who have been trained in collaboration and can produce learning goals approved by all (Stewart, 2014). A professional learning community is formed to identify the needs for improvement in an honest and critical manner. The professional development cycle for a PLC for continuous improvement is the following: "identify student learning needs, identify related teacher learning needs, learn or review concepts, apply concepts to lessons, critique and reflect on lesson" (Stewart, 2014, p. 29).

Learning communities can help in increasing teacher self-efficacy and student achievement. The collaboration of teachers can be linked to Vygotsky's social constructivism. "By participating in a learning community, the participants have an opportunity to collectively inquire and make sense of their experiences through 'collective inquiry" (Taranto, 2011, p. 5). Collaboration allows learners to dialogue about theory and practice and allows differences to be shared and possible practices to be changed. Through collaboration with continuous learning, teachers begin analyzing the strategy, changing the strategy, and receiving information from other learners. They attempt to reflect upon their learning, evaluate, reflect and then share again through collaboration (Voogt & Laferriere, 2015). Teachers can gain knowledge together as a collective and strengthen the group or school as a whole (Kelly & Cherkowski, 2015).

Continuous learning by teachers implies that teachers are "motivated to seek out possible opportunities to acquire knowledge and grow professionally" (Peters-Burton et al., 2015 p. 527). Balach and Szymanski (2003) posited that students cannot be expected to learn unless teachers are active learners as well. Teachers who are continually learning have high expectations for themselves and value the learning process (Peters-Burton et al., 2015). Professional learning communities help teachers continuously learn information from peers in an informal professional development setting. They learn content and pedagogy strategies from other teachers using the PLC model (Richmond & Monokore, 2010).

A typical PLC structure in a school setting includes teachers giving summaries of what has occurred in their classrooms. The other PLC members can offer advice or enrichment in regard to their peers' reports. In a typical PLC, curriculum and assessments are analyzed to determine if they are aligned to learning goals and to assess the impact on student achievement. Formative and summative assessments are generated based on the content. Each topic is discussed and modified to generate a content unit that will increase student achievement. A science PLC may also include identifying student misconceptions on a topic and how inquiry is used to teach a certain content area (Richmond & Monokore, 2010).

Professional development studies focusing on continuing collaboration of teachers have had a positive impact on teachers' beliefs and students' achievements and behavior (Voogt & Laferriere, 2015). Collaboration helps teachers who continuous learn to acquire new information and pass along that information; thus, the learning can take place for multiple teachers in a similar environment. (Balach & Szymanski, 2003). The system of learning with an interactive system has a larger impact than that of a single individual on student achievement (Voogt & Laferriere, 2015).

A PLC professional development is highly adaptive and will focus on different aspects of collaboration and teacher learning. Teachers learn to create a professional community in which participants in the PLC "[share] a common vision and learning from each other" (Richmond & Monokore, 2010, p. 559). The professional community shares information on content, assessment and pedagogy and can help teachers become more confident in their overall teaching practices and knowledge. A PLC can ensure teachers' accountability to their peers and help with the accountability to state measures such as standardized tests. By meeting with peers, the PLC members can be held accountable for the content which is being taught, thereby impacting the accountability measures at a state level (Richmond & Monokore, 2010).

Professional learning communities are not limited to science educators. The PLC model allows teachers to collaborate with diverse professionals to discuss various topics, including pedagogy, content, and student engagement. Professional learning communities can impact student achievement because the model incorporates Vygotsky's ideas on social constructivism, and Knowles' idea of andragogy. Teachers who are self-directed to seek out learning opportunities will be able to learn from each other and teach others in a PLC model.

Examples of Science Education Professional Developments

Professional learning communities are used in the professional development of science educators to increase collaboration, to increase science content knowledge, to increase science pedagogic knowledge, and to help induction teachers learn during their first year in the field.

Professional learning communities have become a part of the professional development cycle (Hamos et al., 2009).

Multiple Math and Science Partnership

Multiple Math and Science Partnership (MSP) grants have used PLCs to deliver professional development content. The MSP grant's professional learning communities often include both K-12 educators and higher education educators (Hamos et al., 2009). One example of an MSP professional development was the North Cascades and Olympic Science Partnership, a partnership that included Western Washington University. The professional development goal was to work with the professional learning communities to help improve student learning. The professional learning communities consisted of 160 teacher leaders. The grant participants were expected to start a PLC in their schools' sites after the initial training. The participants worked with higher education faculty to develop professional development for their school-based PLCs. The school-based professional development was focused on teacher content knowledge and understanding how students learn. Throughout the school year, the PLC used different resources to explore how students learn and to find ways to improve student achievement. The following summer, a content-based professional development opportunity was offered that focused on physical science. After the professional development opportunity was implemented, there was an increase of 19.6% in the number of students who were proficient on the 5th-grade Washington state science assessment (Hamos et al., 2009).

Boston-Science Partnership

Another MSP professional development opportunity that incorporated a PLC was the Boston Science Partnership that collaborated with the University of Massachusetts-Boston. The PLC consisted of science teachers on the same campus meeting once or twice a week for eight to 16 sessions. A staff member from the Boston Science Department initially served as the facilitator of the PLC but, over time, trained a school-based teacher to facilitate, with the goal of the PLC becoming self-sustaining. Topics covered in the PLC were driven by the needs of the individual schools, but topics focused on increasing participating teachers' content knowledge and implementation of pedagogy. The grant evaluators surveyed the participants as part of the evaluation process. The teachers reported that they felt more effective as teachers after participating in the PLC; they also reported an enhanced sense of support from other science teachers and improved communication with peers. Evaluators found that support from administrators is a key factor in the success of the school-based PLC. The evaluators also found that participation in the program increased teacher efficacy and improved teacher retention (Hamos et al., 2009).

Institute for Chemistry Literacy through Computational Science

The Institute for Chemistry Literacy through Computational Science partnered with the University of Illinois-Urbana-Champaign to build PLCs for chemistry teachers. The model for this PLC was a virtual professional learning community that reached out to chemistry teachers in rural areas. The virtual learning community allowed teachers to interact and collaborate without being in the same school district. Because the professional development was virtual, communications could take place at flexible times. The online discussions associated with the virtual learning community were robust and focused on topics of genuine interest to the teachers who participated; they appreciated the opportunity to investigate and think deeply about a specialized topic. Also, more teachers were able to participate because the professional development was virtual; it allowed geographically isolated teachers to interact with peers and experts. The students of the participants in the virtual learning community showed a gain of 45% on the American Standardized Chemical Society standardized test (Hamos et al., 2009).

Project Pathways

Project Pathways, partnering with Arizona State University, was another MSP grant. The PLCs were composed of three to seven teachers who taught the same course. “The project team initially underestimated the support that teachers in PLC’s would need to shift their instruction” (Hamos et al., 2009, p. 19). Initially, teachers struggled to focus on student thinking and learning while trying to integrate inquiry into instruction. The project team videotaped the PLC to identify highly effective PLC models as well as ineffective PLC models. The PLC facilitator was trained to help teachers verbalize vague ideas. When the facilitator was not present, the videos showed teachers having superficial conversations that did not impact classroom practices. Through the analysis of the videotapes, the Pathway researchers realized teachers first need to be able to identify students’ thinking about a topic and decide which pedagogic strategies will be effective before quality inquiry lessons could be developed. Also, it was critical that teachers understand the science content and the pedagogy before shifts in teaching could occur. Extended professional development on content was given after the first year of the project. Researchers found that administrator support is key to successful PLCs at any school level. The conclusions of the study were based on the determination that shifts in teaching practices occurred when teachers were able to reconstruct curriculum using inquiry models (Hamos et al., 2009).

MSP Grant: School District in Eastern North Carolina

The North Carolina Department of Public Instruction awarded an MSP grant to a school district in eastern North Carolina to improve the science content knowledge of middle-grade science teachers. The focus of the grant was to improve teacher efficacy through increased content knowledge, which would have a positive impact on student achievement. The areas the professional development focused on were content courses for teachers throughout the summer and PLCs that met during the school year (Lakshmana, Heath, Perlmutter, & Eler, 2010). The three-year grant project included 107 teachers. The teachers were offered one content course each summer of the three-year grant cycle. A local university provided the courses in a face-to-face or online format. The content was aligned to North Carolina State Standards and was taught using the inquiry method. During the school year, the teachers participated in PLCs that focused on the best practices to teach content and pedagogy for specific topics (Lakshmana et al., 2010).

The measures used by the researcher were the Science Teaching Efficacy Belief Instrument (STEBI) and the Reformed Teaching Observation Protocol (RTOP). The STEBI measures efficacy and is designed for science teachers. The instrument uses a Likert scale to record teacher beliefs about their ability to teach science and beliefs about how students can learn through effective teaching. The RTOP is an observation instrument designed to "provide a quantitative measure of the degree to which teaching is reformed" (Lakshmana et al., 2010, p. 539). The instrument is divided into five sections: (a) lesson design, (b) content knowledge, (c) pedagogical knowledge, (d) classroom culture, and (e) student-teacher relationships (Lakshmana et al., 2010). The analysis of the scores used mean and standard deviations for both instruments. Multivariate models were used to compare the scoring on the instruments. The researchers found that there was a positive impact on efficacy and teacher implementation throughout the three-year cycle. There was also a positive correlation between teachers' scores on both instruments. Researchers hypothesize that efficacy improved because of the continual practice of implementing new strategies and the increase of content knowledge. The study did not include any information on student growth or achievement related to the teachers' efficacy.

MSP Grant: Clark County School District

The Clark County School District in Nevada partnered with the Center for Mathematics and Science Education at the University of Nevada Las Vegas and the Southern Nevada Regional Professional Development Programs to offer professional development for Nevada science teachers. The professional development was funded by the MSP grant, and the need for the professional development was determined by declining statewide assessment scores from elementary through high school. The students were dropping in proficiency from 8th to 10th-grades. The populations that were scoring the lowest on the assessment were Hispanic, African-American, English Language Learners, students with disabilities, and students receiving free and reduced lunch. The goal of the professional development was to train teachers in content areas that were not their specialty and to help students in a 9th-grade integrated curriculum class improve assessment scores. The components for the professional development were to increase science teachers' content and pedagogical knowledge, use PLCs to develop teacher leaders, and to use school-based action research to identify and improve student achievement (Crippen, Blesinger, & Ebert, 2009).

The professional development model had a goal to improve teacher content knowledge through summer institutes that were held at the university. The content was focused on the needs of the teachers who lacked content knowledge in topics covered in the integrated curriculum. The teacher learned the content through inquiry. Throughout the school year, teachers participated in graduate course work that focused on identifying conceptual misconceptions, self-regulated learning, and building equity in the classroom for all students. The PLC of participating teachers met virtually through video conferencing. The final piece of the professional development was the action research, which was designed to help teachers understand how their teaching impacted their students. The action research served as a reflective tool for the teachers to consider how their professional development training was impacting student achievement (Crippen et al., 2009). The level of participation in the professional development varied; participation was highest during the summer institute that focused on astronomy. The impact the professional development had on teacher content knowledge was indicated by a pre and post-assessment that was based on several different standardized assessment inventories. The changes in teacher classroom practices were measured by the Classroom Observation Protocol (COP). The student achievement and proficiency levels were measured using the Nevada High School Proficiency Exam (NHSPE) and the Iowa Test of Educational Development (ITED; Crippen et al., 2009).

The researchers' results showed an increase in teacher content knowledge after participating in the professional development opportunities. The classroom observation tool indicated that teachers involved in the professional development were teacher-centered. "A more explicit connection between the professional development and the participants' classroom is needed to generate a more substantial change in teacher practice" (Crippen et al., 2009, p. 655). Student proficiency improved for the students in the integrated course who had teachers who participated fully in the professional development opportunity (Crippen et al., 2009).

Rice Elementary Model Science Lab

The Rice Elementary Model Science Lab (REMSL) was a partnership between Rice Univerisity and Houston elementary schools to develop professional development for elementary teachers in urban settings. The goal of the professional development was to increase elementary teachers' science content knowledge, to increase teachers' use of inquiry to teach science, and to increase teachers' leadership skills (Diaconum, Radigan, Suskavcevic, & Nichol, 2011). The professional development included 91 in-service teachers for the two-year program. The training included five different focus areas and took place one day a week during the school year. Teachers were instructed in content in the morning sessions and pedagogy in the afternoon (Diaconum et al., 2011). The instruments used to measure the outcomes of the professional development were the Teacher Science Content Test (TSCT) that was given to the participants as a pre and post-assessment. The Reformed Teacher Observation Protocol (RTOP) was used to observe teacher practices in the classrooms of both the participants and non-participants. A survey was developed by Rice University to self-report teaching practices and teacher knowledge in pedagogy and inquiry. A leadership survey, the Survey of Leadership Activities, was administered to self-report leadership growth. Finally, interviews with participants were taped and coded for major themes in relation to content knowledge, inquiry practices, and leadership (Diaconum et al., 2011). The researchers reported growth in teacher content knowledge between the pre and post-assessments. The teachers' percentage of correct answers grew by 14%. The researchers' results for the teacher observation tool had mixed results. There was no statistical significance in the results of the RTOP observation tool. The interviews revealed that teachers' self-efficacy improved and the teachers indicated that the professional development was designed to meet their needs for improved science teaching in content and pedagogy (Diaconum et al., 2011).

The examples in other counties that worked with local universities to offer professional development indicate that school districts focus on improving science content and pedagogy through inquiry. However, the measurement tools, along with the overall results that indicate success, vary. Some researchers focus on student achievement as an indicator of success, while others focus on teacher efficacy as an indicator of success.

Summary

Professional development opportunities help teachers from various certifications continuously learn and develop as teachers. The underlying theories of social constructivism, constructivism, and andragogy provide a framework for professional development learning opportunities to be effective in helping teachers learn new strategies. There is not one specific model for professional development, and it can be formal or informal in nature.

Professional development opportunities in science often include science content knowledge and pedagogical content knowledge. Professional learning communities are developed through facilitation of professional development, but take on a secondary role of being a professional development opportunity for teachers as part of the PLC process. The professional learning communities are used in multiple situations to improve teachers content and pedagogic knowledge.

CHAPTER 3
METHODOLOGY

Introduction

Middle school science teachers in a central Florida school district were given the opportunity to received on-going professional development in content, pedagogy, and collaboration through a Mathematics and Science Partnership (MSP) grant. The teachers who volunteered received 16 days of professional development to increase content knowledge, five days of professional development to increases pedagogical knowledge, and four days of professional development on professional learning communities. In the central Florida school district researched, 12 teachers participated in the ongoing professional development. The teachers comprised a convenience sample, because the teachers volunteered to participate and the sample was not randomly selected.

The content of the professional development the teachers received was provided by the University of South Florida. It included inquiry skills that were embedded in the major content area of Earth/ Space Science, Life Science, and Physical Science, according to the Florida science standards ("CPALMS," 2013). The embedded inquiry skills were science skills that students used to increase their content knowledge, usually in a laboratory environment. The pedagogical knowledge professional development was provided through a vendor with the goal of increasing pedagogy through the enhanced engagement strategies and teaching strategies in the classroom. The professional development in the professional learning community was also provided through a vendor, with the goal of increasing the understanding and importance of collaborating in professional learning communities among middle school science teachers who teach with those who attended the professional development.

Purpose Statement

The purpose of the study was to determine if ongoing professional development in pedagogical strategies, collaboration strategies, and science content impacts student learning as evidenced by an increase in achievement in science content. Increased achievement was measured using scale scores on the school district end-of-year examinations or the statewide science assessment.

Research Questions

1. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participated in three on-going professional development opportunities and the students whose teachers did not participate in three professional development opportunities throughout the 2015-16 school year?
2. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participated in two on-going professional development opportunities and the students whose teachers did not participate in two professional development opportunities throughout the 2015-16 school year?
3. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments of students whose middle school science teachers participates in one on-going professional development opportunity and those students whose teachers did not participate in one or less professional development opportunity throughout the 2015-16 school year?

Population and Sample

The population of this study consisted of middle school science teachers from various middle schools in a central Florida school. In the selected central Florida school district, 12 teachers participated in ongoing professional development. The teachers constituted a convenience sample because the teachers volunteered to participate and were not randomly selected.

The achievement of students whose teachers volunteered to participate in the professional development opportunities was compared to that of students whose teachers did not participate in the professional development opportunities. The population of students associated with this study was analyzed, and sub-group data was analyzed. Participants were grouped according to demographic characteristics and reading level on the Florida Standards Assessment. Groups with less than 10 student participants were eliminated from the study.

Instrumentation

The instruments for the data collection process were the statewide science assessments (SSA) and the end-of-year district science assessments. Eighth-grade students participated annually in the statewide science assessment which assesses students on 6th-, 7th- and 8th-grade science course standards. The assessment item specifications ensured the validity and reliability of the state science assessment, and the test specifications indicated the complexity and difficulty levels of the items for each standard. Science educators reviewed the items after the assessment for content validity, and item statistics were used for reliability purposes (FDOE, 2012).

The content focus report for the SSA for the 2015-2016 school year provided information about the test construct for the previous years. The content focus report for the 2016 SSA showed the points possible for each standard. There may have been more questions on the test than points possible, and field testing was performed for future items. On the 2016 content focus report, there were 56 points possible, 11 in nature of science, 15 in life science, 15 in earth/space science, and 15 in physical science (FDOE, 2016). The content focus report showed the standards that were tested under the content headings but did not give the complexity or discrimination levels of the questions.

The content focus report for the SSA for the 2014-2015 school year provided information about the test construct for the previous years. The content focus report for the 2015 SSA showed the points possible for each standard. There may have been more questions on the test than points possible, and field testing was performed for future items. On the 2015 content focus report, there were 56 points possible, 11 in nature of science, 15 in life science, 15 in earth/space science, and 15 in physical science (FDOE, 2015). The content focus report showed the tested standards under the content headings but did not give the complexity or discrimination levels of the questions.

The item specifications discussed the development of the test items for the SSA grade 8 assessments. The item specifications were written in 2012 and were used through the 2014-2015 and 2015-2016 school years. "The specifications for grade 8 provides general and grade-specific guidelines for the development of all test items used" (FDOE, 2012, p. 12). The cognitive complexity levels of the items, guide lines and suggestions for the multiple choice questions, and difficulty level of items were in the item specification of the SSA. For the SSA, 10% to 20% of the items were classified as low cognitive complexity, 60%-80% were classified as moderate cognitive complexity, and 10% to 20% of the items were classified as high cognitive complexity. The items were reviewed for potential bias and community sensitivity as well (FDOE, 2012)

The instrument for the 7th-grade student achievement information for the 2015-2016 school year was the 7th-grade Earth Science/Space Science end-of-year assessment developed by the central Florida school district involved in the study. The 7th-grade end-of-year assessment was aligned to the course standards for M/J Earth Science/Space Science and M/J Earth Science/Space Science Advanced. The school district science specialist and course instructors developed the assessment blue print for the assessment based on the course standards listed in the course description as described by the FDOE ("CPALMS," 2013). The assessment contained 33 questions. The test blueprint listed the standard, level of complexity, content limitations, and number of questions tested for that standard. The blue print was available for viewing on the central Florida school districts website (Torres, Seabolt, & Pierce, 2016).

The content validity for the end-of-year assessment was review by two district science specialists. The specialists reviewed the blueprint and course information to determine the item alignment to the course standards and complexity levels listed on the blueprints (University, 2013). The Cronbach alpha, which is a value that determines the reliability of an assessment, was .783, using SPSS statistical software. The formula for Cronbach alpha is $\alpha = \frac{NC}{V+(N-1)C}$ (Steinberg, 2011). The items difficulty and discrimination were determined using the R studio statistical software.

The instrument for the 7th-grade student achievement information for the 2014-2015 school year was the 7th-grade Earth Science/Space Science end-of-year assessment developed by the central Florida school district involved in the study. The 7th-grade end-of-year assessment was aligned to the course standards for M/J Earth Science/Space Science and M/J Earth Science/Space Science Advanced. The school district science specialist and course instructors developed the assessment blue print for the assessment based on the course standards listed in the course description as described by the FDOE (“CPALMS,” 2013). The assessment contained 40 questions. The test blueprint listed the standard, level of complexity, content limitations, and number of questions tested for that standard. The blue print was available for viewing on the central Florida school districts website (Torres et al., 2016).

The content validity for the end-of-year assessment was review by two district science specialists. The specialists reviewed the blueprint and course information to determine the item alignment to the course standards and complexity levels listed on the blueprints (“CPALMS,” 2013). The Cronbach alpha, which is a value that determines the reliability of an assessment, was .818, using SPSS statistical software. The formula for Cronbach alpha is $\alpha = \frac{NC}{V+(N-1)C}$ (Steinberg, 2011). The items’ difficulty and discrimination were determined using the SPSS statistical software.

The instrument for the 6th-grade student achievement information for the 2015-2016 school year was the 6th-grade life science end-of-year assessment developed by the central Florida school district involved in the study. The 6th-grade end-of-year assessment was aligned to the course standards for M/J Life Science and M/J Life Science Advanced. The school district science specialist and course instructors developed the assessment blue print for the assessment based on the course standards listed in the course description. The test had 33 questions. The test blueprint listed the standard, level of complexity, content limitations and number of questions tested for the standard. The blue print was available for viewing on the central Florida school district's website (Torres et al., 2016).

The content validity for the end-of-year assessment for 2015-2016 was reviewed by two district science specialists. The specialists reviewed the blueprint and course information to determine the items alignment to the course standards and complexity levels listed on the blueprints. The Cronbach alpha, which is a value that determines the reliability of an assessment, was .854 using SPSS statistical software. Cronbach alpha is a measure of internal reliability. The formula for Cronbach alpha is $\alpha = \frac{NC}{V+(N-1)C}$ (Steinberg, 2011). To add to the measure of reliability, the difficulty and discrimination of items were determined using the SPSS statistical software to establish how the items discriminated and how difficult the items were on the assessment.

The instrument for the 6th-grade student achievement information for the 2014-2015 school year was the 6th-grade life science end-of-year assessment developed by the central Florida school district involved in the study. The 6th-grade end-of-year assessment was aligned to the course standards for M/J Life Science and M/J Life Science Advanced. The school district science specialist and course instructors developed the assessment blue print for the assessment based on the course standards listed in the course description. The test had 40 questions. The test blueprint listed the standard, level of complexity, content limitations and number of questions tested for the standard. The blue print was available for viewing on the central Florida school district's website (Torres et al., 2016).

Two district science specialists reviewed the content validity for the end-of-year assessment. The specialists reviewed the blueprint and course information to determine the items alignment to the course standards and complexity levels listed on the blueprints. The Cronbach alpha, which is a value that determines the reliability of an assessment, was .864 using SPSS statistical software. Cronbach alpha is a measure of internal reliability. The formula for Cronbach alpha is $\alpha = \frac{NC}{V+(N-1)C}$ (Steinberg, 2011). To add to the measure of reliability, the difficulty and discrimination of items were determined using the SPSS software to establish how the items discriminated and how difficult the items were on the assessment.

Data Collection

The data collection process included multiple different data points based on the grade level taught by the teacher. Depending on the grade level, different student data were collected. The students enrolled in certain science classes, which were isolated by course code, were used in the data collection process for all of the central Florida school district being researched. The courses for which data were collected are displayed in Table 3.

Table 3

Science Assessment: Courses and Instrumentation by Grade Level

Courses	Instrumentation
M/J Life Science #2000010 M/J Life Science Advanced #2000020 M/J International Baccalaureate MYP Life Science #2000030	District administered end-of-year examination for 6th-grade Life Science
M/J Earth Science #2001010 M/J Earth/Space Science Advanced #2001020 M/J International Baccalaureate MYP Earth/Space Science 2001030	District administered end-of-year examination for 7th-grade Earth/Space science
M/J Comprehensive science 3 #2002100 M/J Comprehensive Science 3 Advanced # 2002110 M/J International Baccalaureate MYP Comprehensive Science 3 #2002200 Physical Science Honors #2003320	Statewide science assessments administered by the Florida Department of Education

Source. ("CPALMS," 2013)

The State Science Assessments for 2014-2015 and 2015-2016 were administered as a paper-based assessment through the FDOE. The assessment had a time limit of two 80-minute sessions, but accommodations were given to students who had extended time granted through an identification by the state of a learning disability or medical extension. The results were provided through the assessment vendors' website to district personnel. The 6th-grade Life Science assessment and the 7th-grade Earth/ Space Science assessments were administered through the free item bank and test platform (IBTP) provided by the FDOE to Florida school districts for the 2015-2016 school year and through the local platform for the 2014-2015 school year. The test administration was up to 70 minutes, and extended time was given to students following the same guidelines as the Statewide Science assessment. The results are found on the IBTP platform, and district personnel had access to student assessment scores for the 2015-2016 school year, and in the local platform for the 2014-2015 school year. Student demographic information including gender, race, ethnicity, free and reduced lunch status, school location, and grade level were gathered for each student in the courses listed in Table 3 through the information system, FOCUS. Permission to use de-identified student and teacher information was granted by the director of Research and Accountability in the central Florida school district that was awarded the MSP grant and participated in the study. The researcher received approval to conduct this study from the Institutional Review Board from the University of Central Florida (Appendix A) and from the School District of Osceola County (Appendix B).

Data Analysis

The student data were divided into groups based on de-identified teacher information, including the number of professional development opportunities teachers attended throughout the 2015-2016 school year, student scale score and performance level on the Florida Standards Assessment (FSA) for English Language Arts (ELA), selected demographic information, and science assessment scale score and performance level. The data were grouped according to the degree of teacher participation in the professional development opportunities. The teachers participating in the professional development were assigned into different treatment groups based on the number of professional development they attended. Teachers who did not attend any professional development opportunities through the MSP grant served as a control group. Teachers were also grouped by the assessment tied to the course they taught.

The data were propensity score matched to adjust for selection bias between the teachers who received the opportunity to participate in professional development and those who did not (Bersamin, Garbers, Gaarde, & Santelli, 2016). The propensity score matching was based on percent of students at each reading level on the FSA ELA assessment. The FSA ELA assessment was selected because of the high correlation between district and state science assessment and the FSA ELA assessments (Table 4). Correlation is statistical measure used to determine if variables are related, in this case FSA ELA reading and district and state science assessments. Scores with strong relationships have a correlation between .5 and 1 (Steinberg, 2011).

Table 4

Correlation between Science Instruments and FSA ELA Assessment

Assessments	*r*
Assessments 15-16	
District administered end-of-year examination for 6th-grade Life Science to FSA ELA assessment	.705
District administered end-of-year examination for 7th-grade Earth/Space science to FSA ELA assessment	.572
Statewide science assessments administered by the Florida Department of Education to FSA ELA assessment	.750
Assessments 14-15	
District administered end-of-year examination for 6th-grade Life Science to FSA ELA assessment	.734
District administered end-of-year examination for 7th-grade Earth/Space science to FSA ELA assessment	.681
Statewide science assessments administered by the Florida Department of Education to FSA ELA assessment	.804

The data were then imported into SPSS version 24, 2016 (statistical software program), and a mean score was "computed by adding up all the scores and dividing the result by the number of scores" (Welkowitz, Ewen, & Cohen, 1988, p. 48); the equation is $M = \frac{\Sigma X}{N}$ (Steinberg, 2011). The z score was determined based the student assessment scores. The z score is a "technique to switch the original score to a scale score with a mean of zero and a standard deviation of 1" (Welkowitz et al., 1988, p. 74); the equation is $z = \frac{X-M}{s}$ (Steinberg, 2011). For example, the mean scale score for a student with an achievement level of one on the FSA was determined.

The students' science assessment scores or end-of-year assessment scores were then categorized using de-identified teacher information, class period, reading level, English language learner (ELL) status, student with disability status (SWD), and free and reduced lunch (FRL) status. The mean and *z* score average was determined based on the number of professional development opportunities attended and compared to the control group. The different average *z* scores were separated by different groupings to look for statistical significance using independent *t*-tests.

An independent sample *t*-test measures the differences in means and tests for significance. The formula for the independent sample *t*-test is the mean of the first sample minus the mean of the second sample minus the mean of the first population minus the mean of the second population divided by the standard error of difference between the means. $t_{2-samp} = (M_1 - M_2) - (\mu_1 - \mu_2 / \sigma_{m1-m2})$ is the formula. The null hypothesis can be rejected if the significance is at a 95% confidence interval. The 95% confidence interval is a "range of scores within which a parameter probably falls, with a given degree of probability" (Steinberg, 2011, p. 218). If the significance is above a .05, the null hypothesis is accepted with a 95% confidence (Steinberg, 2011).

Additional data collected for this study included the examination data (district create end-of-year exam) for students whose teachers participated in this study. The examination scores' mean and z score were determined for the entire district and then aggregated by reading level and demographic sub-group factors to determine statistical significance.

The analysis of the data determined if the null hypothesis was valid. The data analysis determined if teachers' participation in the professional development opportunities impacted their students' achievement, with the data being aggregated to decide if the professional development of middle school science teachers had an impact on student achievement. Data were aggregated by reading level and sub-group information to determine if the professional development of teachers had a statistically significant impact.

The teachers in this study who participated in the opportunities for professional development sought to increase their content knowledge, pedagogical knowledge, and collaboration skills. The analysis of the data enabled the researcher to determine if there was a statistically significant difference in student achievement between the students whose teachers participated in professional development opportunities and the students whose teachers did not participate. Based on the findings, overall recommendations related to the different sub-group results were developed.

CHAPTER 4
DATA ANALYSIS

Purpose Statement

The study was conducted to determine if ongoing professional development in pedagogical strategies, collaboration strategies, and science content knowledge impacted student achievement as evidenced by a rise in science scores. Increased achievement was measured using scale scores on the school district end-of-year examinations or the statewide science assessment. The researcher examined the impact professional development in the area of science content, pedagogy, and professional learning communities had on student achievement.

Data Collection

The data for this study was provided by the central Florida research and accountability department. The data was de-identified for the sixth, seventh and eighth grade students' end-of-year assessments and state science assessment for the 2015-2016 and 2014-2015 school years. The 2014-2015 data served as a baseline for gauging participants' professional development. The teachers were de-identified, with numbers indicating teachers who participated in the professional development and how many professional development activities attended; teachers who did not participate in the professional development were de-identified with the acronym "NP." Student demographic information was also indicated in the data, including:

- English language learner (ELL),
- Student with disability (SWD),
- Free and reduced lunch status,
- Prior year achievement level on the FSA ELA assessment, and

- Student grade level.

Based on prior year FAS ELA assessments, the data was propensity score matched. Propensity score matching (PSM) allows for variances to be lowered in matching populations and allowed for the *N* of the students to be similar in quantity and achievement levels. Propensity score matching was utilized to compare non-participants' students and participants' students for the 2014-2015 school year and the 2015-2016 school year.

The collected data was then imported into the statistical software package SPSS version 24, 2016 for analysis. Using SPSS, students' scores were converted into *z*-scores to normalize the data for comparison. The *z*-scores were used to generate the independent samples *t*-test of means; *t*-tests are used to determine if there is a significant difference between means (Steinberg, 2011). Significance exists if the variance can be determined with 95% confidence that the differences in the means were based on the professional development attended. If the significance is higher than .05, then the difference between the means is not significant with 95% confidence.

Research Questions

1. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participated in three on-going professional development opportunities and the students whose teachers did not participant three professional development opportunities throughout the 2015-16 school year?
2. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science

teachers participated in two on-going professional development opportunities and the students whose teachers did not participate in two professional development opportunities throughout the 2015-16 school year?

3. What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments of students whose middle school science teachers participates in one on-going professional development opportunity and those students whose teachers did not participate in one or less professional development opportunity throughout the 2015-16 school year?

<u>Research Question 1: Teachers Who Attended Three Professional Development Opportunities</u>

The first research question compared the assessment scores of students whose teachers attended three professional development opportunities to the assessment scores of students whose teachers did not attend the professional development opportunities.

The mean assessment score of the 6th-grade students whose teachers who did not participate in the three professional development opportunities ($M = .052$) was higher than the mean assessment score of the 6th-grade students whose teachers did participate in the three professional development opportunities ($M = -.052$; Table 5). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students of the non-participating teachers ($M = .052$, $SD = 1.01$) and the 6th-grade students of the participating teachers [($M = -.052$, $SD = .992$), $t(634) = 1.32$, $p = .186$]. The mean assessment score of the 7th-grade students whose teachers participated in the three professional development opportunities ($M = .490$) was higher than the mean assessment score of the 7th-grade students whose teachers did not participate in the three professional development opportunities (*M* = -.505). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students of the non-participating teachers (*M* = -.505, *SD* = .738) and the 7th-grade students of the participating teachers [(*M* = .490, *SD* = .979), *t*(232) = 10.7, *p* = .000]. The mean assessment score of the 8th-grade students whose teachers who did not participate in the three professional development opportunities (*M* = .012) was higher than the mean assessment score of the 8th-grade students whose teachers participated in the three professional development opportunities (*M* = -.012). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students of the non-participating teachers (*M* = .012, *SD* = 1.02) and the 8th-grade students of the participating teachers [(*M* = -.119, *SD* = .995), *t*(1141) = -.407, *p* = .684].

Table 5

Student Assessment Scores: Results Including Means and Significance of T-tests for Teachers Participating in Three Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIU	CIL
6th grade	Participating	317	-.057	.992	1.32	634	.186	-.26	.05
	Non-Participating	320	.052	1.01					
7th grade	Participating	175	.490	.979	10.7	323	.000	.811	1.17
	Non-Participating	170	-.505	.738					
8th grade	Participating	580	-.119	.995	-.407	1141	.684	-.140	.092
	Non-Participating	563	.012	1.02					

Subgroup Data: ELL, ESE, Free and Reduced Lunch, Achievement Levels for Teachers Who Attended 3 Professional Development Opportunities

The mean assessment score of the 6th-grade ELL students whose teachers who did participate in the three professional development opportunities (M = -.676) was higher than the mean assessment score of the 6th-grade ELL students whose teachers did not participate in the three professional development opportunities (M = -.779; Table 6). An independent sample t-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade ELL students of the non-participating teachers (M = -.779, SD = .678) and the 6th-grade ELL students of the participating teachers [(M = -.676, SD = .735), $t(64)$ = -.950, p = .556]. The mean assessment score of the 7th-grade ELL students whose teachers participated in the three professional development opportunities (M = .768) was higher than the mean assessment score of the 7th-grade ELL students whose teachers did not participate in the three professional development opportunities (M = -.422). An independent sample t-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade ELL students of the non-participating teachers (M = -.422, SD = .750) and the 7th-grade ELL students of the participating teachers [(M = -.768, SD = 1.02), $t(47)$ = 4.67, p = .000]. The mean assessment score of the 8th-grade ELL students whose teachers participated in the three professional development opportunities (M = -.853) was higher than the mean assessment score of the 8th-grade ELL students whose teachers did not participate in the three professional development opportunities (M = -.915). An independent sample t-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade ELL students of the non-participating teachers (M = .915, SD = 1.01) and the 8th-grade ELL students of the participating teachers [(M = -.853, SD = 1.16), $t(83)$ = .259, p = .796].

Table 6

ELL Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level (ELL)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CLU
6th Grade	Participating	34	-.676	.735	-.950	64	.556	-.244	.085
	Non Participating	32	-.779	.678					
7th Grade	Participating	25	.768	1.33	4.65	47	.000	.676	1.71
	Non-Participating	24	-.422	.750					
8th Grade	Participating	31	-.853	1.16	.259	83	.796	-.256	-.022
	Non-Participating	54	-.915	1.01					

The mean assessment score of the 6th-grade SWD students whose teachers who did not participate in the three professional development opportunities (*M* = -.783) was higher than the mean assessment score of the 6th-grade SWD students whose teachers participated in the three professional development opportunities (*M* = -.733; Table 7). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade SWD students of the non-participating teachers (*M* = -.783, *SD* = .627) and the 6th-grade SWD students of the participating teachers [(*M* = -.733, *SD* = .917), *t*(50) = -.233, *p* = .817]. The mean assessment score of the 7th-grade SWD students whose teachers participated in the three professional development opportunities (*M* = -.060) was higher than the mean assessment score of the 7th-grade SWD students whose teachers did not participate in the three professional development opportunities (*M* = -.511). An independent sample *t*-test was performed and there was not a significant difference between the mean assessment scores of the 7th-grade SWD students of the non-participating teachers (*M* = -.511, *SD* = .786) and the 7th-grade SWD students of the participating teachers [(*M* = -.060, *SD* = .993), *t*(32) = 1.57, *p* = .127]. The mean assessment score of the 8th-grade SWD students whose teachers did not participate in the three professional development opportunities (*M* = -.673) was higher than the mean assessment score of the 8th-grade SWD students whose teachers participated in the three professional development opportunities (*M* = -.762). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade SWD students of the non-participating teachers (*M* = -.673, *SD* = 1.02) and the 8th-grade SWD students of the participating teachers [(*M* = -.762, *SD* = .981), *t*(132) = -.514, *p* = .608].

Table 7

SWD Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level (SWD)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CLU
6th grade	Participating	30	-.783	.627	-.233	50	.817	-.479	.380
	Non-Participating	22	-.733	.917					
7th grade	Participating	18	-.059	.993	1.57	32	.127	-.118	1.02
	Non-Participating	22	-.511	.786					
8th grade	Participating	77	-.762	.981	-.514	132	.608	-.435	.256
	Non-Participating	57	-.673	1.023					

The mean assessment score of the 6th-grade students (free or reduced lunch) whose teachers who did not participate in the three professional development opportunities (*M* = -.118) was higher than the mean assessment score of the 6th-grade students (free or reduced lunch) whose teachers did participate in the three professional development opportunities (*M* = -.180; Table 8). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (free or reduced lunch) of the non-participating teachers (*M* = -.118, *SD* = .967) and the 6th-grade students (free or reduced lunch) of the participating teachers [(*M* = -.180, *SD* = .935), *t*(361) = -.613, *p* = .540]. The mean assessment score of the 7th-grade students (free or reduced lunch) whose teachers participated in the three professional development opportunities (*M* = .383) was higher than the mean assessment score of the 7th-grade students (free or reduced lunch) whose teachers did not participate in the three professional development opportunities (*M* = -.571). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students (free or reduced lunch) of the non-participating teachers (*M* = -.571, *SD* = .708) and the 7th-grade students (free or reduced lunch) of the participating teachers [(*M* = .383, *SD* = .976), *t*(201) = 8.25, *p* = .000]. The mean assessment score of the 8th-grade students (free or reduced lunch) whose teachers who did not participate in the three professional development opportunities (*M* = .186) was higher than the mean assessment score of the 8th-grade students (free or reduced lunch) whose teachers did not participate in the three professional development opportunities (*M* = -.019). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 8th-grade students (free or reduced lunch) of the non-participating teachers (*M* = .186, *SD* = .940) and the 8th-grade students (free or reduced lunch) of the participating teachers [(*M* = -.019, *SD* = .915), *t*(388) = -2.18, *p* = .030].

Table 8

FRL Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level (FRL)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CLU
6th Grade	Participating	200	-.180	.935	-.613	361	.540	-.313	.184
	Non-Participating	163	-.118	.967					
7th Grade	Participating	111	.383	.976	8.25	201	.000	.726	1.18
	Non-Participating	104	-.571	.708					
8th Grade	Participating	214	-.019	.915	-2.18	388	.03	-.390	-.020
	Non-Participating	176	.186	.940					

The mean assessment score of the 6th-grade students (ELA FSA Level 1) whose teachers did not participate in the three professional development opportunities (*M* = -.733) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 1) whose teachers did participate in the three professional development opportunities (*M* = -.784; Table 9). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -.733, *SD* = .727) and the 6th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = -.784, *SD* = .633), *t*(188) = -.515, *p* = .608]. The mean assessment score of the 7th-grade students (ELA FSA Level 1) whose teachers participated in the three professional development opportunities (*M* = .378) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 1) whose teachers did not participate in the three professional development opportunities (*M* = -.690). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -.690, *SD* = .929) and the 7th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = .376, *SD* = .928), *t*(177) = 9.175, *p* = .000]. The mean assessment score of the 8th-grade students (ELA FSA Level 1) whose teachers participated in the three professional development opportunities (*M* = -.102) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 1) whose teachers did not participate in the three professional development opportunities (*M* = -1.11). An independent sample *t*-test was performed and there was not a significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -1.11, *SD* = .750) and the 8th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = -1.02, *SD* = .747), *t*(327) = 1.24, *p* = .215].

Table 9

ELA Level 1 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level (ELA LEVEL 1)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	95	-.784	.633	-.515	188	.607	-.246	.144
	Non-Participating	95	-.733	.727					
7th Grade	Participating	98	.376	.929	9.175	194	.000	.836	1.29
	Non-Participating	98	-.689	.677					
8th Grade	Participating	166	-1.02	.747	1.24	327	.215	-.060	.265
	Non-Participating	163	-1.12	.750					

The mean assessment score of the 6th-grade students (ELA FSA Level 2) whose teachers did not participate in the three professional development opportunities (*M* = -.148) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 2) whose teachers did participate in the three professional development opportunities (*M* = -.267; Table 10). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 2) of the non-participating teachers (*M* = -.148, *SD* = .728) and the 6th-grade students (ELA FSA Level 2) of the participating teachers [(*M* = -.266, *SD* = .862), *t*(191) = -.998, *p* = .319]. The mean assessment score of the 7th-grade students (ELA FSA Level 2) whose teachers participated in the three professional development opportunities (*M* = .739) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 2) whose teachers did not participate in the three professional development opportunities (*M* = -.333). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 2) of the non-participating teachers (*M* = -.333, *SD* = .725) and the 7th-grade students (ELA FSA Level 2) of the participating teachers [(*M* = .739, *SD* = .975), *t*(100) = 6.30, *p* = .000]. The mean assessment score of the 8th-grade students (ELA FSA Level 2) whose teachers did not participate in the three professional development opportunities (*M* = -.075) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 2) whose teachers participated in the three professional development opportunities (*M* = -.174). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 2) of the non-participating teachers (M = -.075, SD = .553) and the 8th-grade students (ELA FSA Level 2) of the participating teachers [(M = -.174, SD = .619), t(239) = -1.32, p = .188].

Table 10

ELA Level 2 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level (ELA LEVEL 2)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	95	-.267	.862	-.998	191	.319	-.353	.115
	Non-Participating	98	-.148	.786					
7th Grade	Participating	51	.739	.975	6.30	100	.000	.735	1.41
	Non- Participating	51	-.334	.725					
8th Grade	Participating	121	-.174	.619	-1.32	239	.188	-.249	.049
	Non-Participating	120	-.075	.553					

The mean assessment score of the 6th-grade students (ELA FSA Level 3) whose teachers did not participate in the three professional development opportunities (M = .514) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 3) whose teachers did participate in the three professional development opportunities (M = .338; Table 11). An independent sample t-test was performed and there was a significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 3) of the non-participating teachers (M = .514, SD = .698) and the 6th-grade students (ELA FSA Level 3) of the participating teachers [(M = .338, SD = .728), t(147) = -1.51, p = .134]. The mean assessment score of the 7th-grade students (ELA FSA Level 3) whose teachers participated in the three professional development opportunities (M = .516) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 3) whose teachers did not participate in the three professional development opportunities (*M* =- .010). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 3) of the non-participating teachers (*M* = -.010, *SD* = .703) and the 7th-grade students (ELA FSA Level 3) of the participating teachers [(*M* = .516, *SD* = .891), *t*(32) = 1.91, *p* = .065]. The mean assessment score of the 8th-grade students (ELA FSA Level 3) whose teachers did not participate in the three professional development opportunities (*M* = .490) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 3) whose teachers participated in the three professional development opportunities (*M* = .418). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 3) of the non-participating teachers (*M* = -.490, *SD* = .556) and the 8th-grade students (ELA FSA Level 3) of the participating teachers [(*M* = .418, *SD* = .549), *t*(360) = -1.23, *p* = .220].

Table 11

ELA Level 3 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level (ELA LEVEL 3)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	74	.338	.728	-.515	188	.134	-.246	.144
	Non Participating	75	.514	.670					
7th Grade	Participating	17	.516	.891	6.3	100	.065	.735	1.40
	Non Participating	17	-.009	.703					
8th Grade	Participating	181	.418	.548	-1.23	360	.220	-.186	.043
	Non Participating	181	.489	.556					

The mean assessment score of the 6th-grade students (ELA FSA Level 4) whose teachers did not participate in the three professional development opportunities (*M* = .949) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 4) whose teachers did participate in the three professional development opportunities (*M* = 1.13; Table 12). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 4) of the non-participating teachers (*M* = .949, *SD* = .681) and the 6th-grade students (ELA FSA Level 4) of the participating teachers [(*M* = 1.13, *SD* = .806), *t*(89) = -1.17, *p* = .247]. The 7^{th} grade participant courses had an n of 1 for the students scoring a level 4 on the FSA ELA, which is too small of a sample size for analysis. The mean assessment score of the 8th-grade students (ELA FSA Level 4) whose teachers participated in the three professional development opportunities (*M* = 1.10) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 4) whose teachers did not participate in the three professional development opportunities (*M* = 1.03). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 4) of the non-participating teachers (*M* = 1.03, *SD* = .513) and the 8th-grade students (ELA FSA Level 4) of the participating teachers [(*M* = 1.10, *SD* = .507), *t*(166) = .842, *p* = .401].

Table 12

ELA Level 4 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Developments

Student Grade-level (ELA LEVEL 4)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	46	.949	.681	-1.17	89	.247	-.493	.129
	Non Participating	45	1.13	.806					
7th Grade	Participating	1	—	—	—	—	—	—	—
	Non Participating	1	—	—	—	—	—	—	—
8th Grade	Participating	84	1.10	.507	-1.17	28	.401	-.089	.221
	Non Participating	84	1.034	.512					

The number of students scoring a level 5 on the FSA ELA who were in enrolled in 6th and 7th grade courses and had teachers that participated in the three professional development opportunities was too small of a sample to perform an analysis. The mean assessment score of the 8th-grade students (ELA FSA Level 5) whose teachers did not participate in the three professional development opportunities (*M* = 1.53) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 5) whose teachers participated in the three professional development opportunities (*M* = 1.34; Table 13). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 2) of the non-participating teachers (*M* = 1.53, *SD* = .373) and the 8th-grade students (ELA FSA Level 5) of the participating teachers [(*M* = 1.34, *SD* = .373), *t*(28) = -1.17, *p* = - .189].

Table 13

ELA Level 5 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level (ELA LEVEL 5)	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	7	—	—	—	—	—	—	—
	Non-Participating	7	—	—	—	—	—	—	—
7th Grade	Participating	0	—	—	—	—	—	—	—
	Non-Participating	0	—	—	—	—	—	—	—
8th Grade	Participating	15	1.34	.503	-1.17	28	.253	-.520	.142
	Non-Participating	15	1.53	.373					

Research Question 2: Teachers Who Attended Two Professional Development Opportunities

The second research question compared students' assessment scores of the teachers who attended two professional development opportunities and students' assessment scores of teachers who did not attend professional development opportunities.

The mean assessment score of the 6th-grade students whose teachers who did participated in the two professional development opportunities (*M* = .034) was higher than the mean assessment score of the 6th-grade students whose teachers did not participate in the two professional development opportunities (*M* = -.034; Table 14). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the students of the non-participating teachers (*M* = -.034, *SD* = 1.03) and the students of the participating teachers [(*M* = .034, *SD* = .967), *t*(734) = .926, *p* = -.335]. The mean assessment score of the 7th-grade students whose teachers participated in the two professional development opportunities (*M* = .165) was higher than the mean assessment score of the 7th-grade students whose teachers did not participate in the two professional development opportunities (*M* = -.165). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the students of the non-participating teachers (*M* = -.165, *SD* = .928) and the students of the participating teachers [(*M* = .165, *SD* = 1.03), *t*(577) = 3.95, p = -.000]. The mean assessment score of the 8th-grade students whose teachers who did not participate in the two professional development opportunities (*M* = .020) was higher than the mean assessment score of the 8th-grade students whose teachers participated in the two professional development opportunities (*M* = -.020). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the students of the non-participating teachers (*M* = .020, *SD* = 1.06) and the students of participating teachers [(*M* = -.020, *SD* = .943), *t*(365) = -.365, p = .695].

Table 14

Student Assessment Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	374	.034	.967	.926	743	.355	-.076	.211
	Non- Participating	371	-.034	1.03					
7th Grade	Participating	280	.165	.928	3.95	577	.000	.166	.494
	Non-Participating	279	-.165	1.04					
8th grade	Participating	186	-.020	.943	-.393	365	.695	-.247	.164
	Non-Participating	181	.020	1.057					

Subgroup data: ELL, ESE, Free and Reduced Lunch, Achievement Levels for Teachers who attended 2 Professional Development Opportunities

The mean assessment score of the 6th-grade ELL students whose teachers who participated in the two professional development opportunities (*M* = .554) was higher than the mean assessment score of the 6th-grade ELL students whose teachers did not participate in the two professional development opportunities (*M* = -.972; Table 15). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade ELL students of the non-participating teachers (*M* = -.972, *SD* = .790) and the 6th-grade ELL students of the participating teachers [(*M* = -.554, *SD* = 1.03), *t*(45) = 1.57, *p* = .124]. The mean assessment score of the 7th-grade ELL students whose teachers participated in the two professional development opportunities (*M* = -.378) was higher than the mean assessment score of the 7th-grade ELL students whose teachers did not participate in the two professional development opportunities (*M* = -.598). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 7th-grade ELL students of the non-participating teachers (*M* = -.598, *SD* = .743) and the 7th-grade ELL students of the participating teachers [(*M* = -.378, *SD* = 1.10), *t*(34) = .686, *p* = .498]. The mean assessment score of the 8th-grade ELL students whose teachers who did not participate in the two professional development opportunities (*M* = -.339) was higher than the mean assessment score of the 8th-grade ELL students whose teachers participated in the two professional development opportunities (*M* = -.892). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade ELL students of the non-participating teachers (*M* = -.339, *SD* = 1.10) and the 8th-grade ELL students of the participating teachers [(*M* = -.892, *SD* = .860), *t*(41) = -1.83, *p* = .073].

Table 15

ELL Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level ELL	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	18	-.554	1.03	1.57	45	.124	-.119	.955
	Non- Participating	29	-.972	.790					
7th Grade	Participating	20	-.378	1.10	.686	34	.498	-.433	.873
	Non-Participating	16	-.598	.743					
8th Grade	Participating	26	-.893	.860	-1.84	41	.093	-1.16	.055
	Non-Participating	17	-.339	1.11					

The mean assessment score of the 6th-grade SWD students whose teachers who did not participate in the two professional development opportunities (*M* = -.904) was higher than the mean assessment score of the 6th-grade SWD students whose teachers participated in the two professional development opportunities (*M* = -.915; Table 16). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade SWD students of the non-participating teachers (*M* = -.904, *SD* = .830) and the 6th-grade SWD students of the participating teachers [(*M* = -.915, *SD* = .742), $t(57) = -.055$, $p = .237$]. The mean assessment score of the 7th-grade SWD students whose teachers participated in the two professional development opportunities (*M* = -.608) was higher than the mean assessment score of the 7th-grade SWD students whose teachers did not participate in the two professional development opportunities (*M* = -.763). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade SWD students of the non-participating teachers (*M* = -.763, *SD* = 1.17) and the 7th-grade

SWD students of the participating teachers [(*M* = -.608, *SD* = .905), *t*(52) = .548, *p* = .000]. The mean assessment score of the 8th-grade SWD students whose teachers who did not participate in the two professional development opportunities (*M* = -.763) was higher than the mean assessment score of the 8th-grade SWD students whose teachers participated in the two professional development opportunities (*M* = -.608). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade SWD students of the non-participating teachers (*M* = -.763, *SD* = 1.32) and the 8th-grade SWD students of the participating teachers [(*M* = - .685, *SD* = .771), *t*(29) = -.291, *p* = .773].

Table 16

SWD Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level ELL	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	32	-.915	.752	-.055	57	.237	-.421	.399
	Non- Participating	27	-.904	.830					
7th Grade	Participating	29	-.608	.904	4.25	503	.586	.194	.527
	Non-Participating	25	-.762	1.17					
8th Grade	Participating	14	-.685	.771	-.291	29	.773	-.935	.702
	Non-Participating	17	-.569	1.32					

The mean assessment score of the 6th-grade students (free or reduced lunch) whose teachers who participated in the two professional development opportunities (*M* = -.104) was higher than the mean assessment score of the 6th-grade students (free or reduced lunch) whose teachers did participate in the two professional development opportunities (*M* = -.240; Table 17).

An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (free or reduced lunch) of the non-participating teachers (M = -.240, SD = .932) and the 6th-grade students (free or reduced lunch) of the participating teachers [(M = -.104, SD = .771), t(419) = 1.51, p = .132]. The mean assessment score of the 7th-grade students (free or reduced lunch) whose teachers participated in the two professional development opportunities (M = .018) was higher than the mean assessment score of the 7th-grade students (free or reduced lunch) whose teachers did not participate in the two professional development opportunities (M = -.318). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students (free or reduced lunch) of the non-participating teachers (M = -.318, SD = 1.03) and the 7th-grade students (free or reduced lunch) of the participating teachers [(M = .018, SD = .957), t(322) = 3.00, p = .003]. The mean assessment score of the 8th-grade students (free or reduced lunch) whose teachers who did not participate in the two professional development opportunities (M = .833) was higher than the mean assessment score of the 8th-grade students (free or reduced lunch) whose teachers did not participate in the two professional development opportunities (M = -.161). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (free or reduced lunch) of the non-participating teachers (M = .833, SD = 1.11) and the 8th-grade students (free or reduced lunch) of the participating teachers [(M = -.161, SD = .896), t(80) = -3.87, p = .000].

Table 17

FRL Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level ELL	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	207	-.104	.908	1.51	419	.132	-.041	.311
	Non- Participating	207	-.240	.932					
7th Grade	Participating	138	.018	.957	3.00	322	.003	.116	.557
	Non-Participating	186	-.318	1.025					
8th Grade	Participating	65	-.161	.906	-3.874	80	.000	-1.50	-.483
	Non-Participating	17	.833	1.101					

The mean assessment score of the 6th-grade students (ELA FSA Level 1) whose teachers participated in the two professional development opportunities (*M* = -.885) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 1) whose teachers did not participate in the two professional development opportunities (*M* = -1.032; Table 18). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -1.032, *SD* = .649) and the 6th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = -.885, *SD* = .700), $t(156) = 1.37$, $p = .171$]. The mean assessment score of the 7th-grade students (ELA FSA Level 1) whose teachers participated in the two professional development opportunities (*M* = -.532) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 1) whose teachers did not participate in the two professional development opportunities (*M* = -.674). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the

7th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -.647, *SD* = 1.11) and the 7th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = -.532, *SD* = .813), *t*(158) = .926, *p* = .356]. The mean assessment score of the 8th-grade students (ELA FSA Level 1) whose teachers participated in the two professional development opportunities (*M* = -1.21) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 1) whose teachers did not participate in the two professional development opportunities (*M* = -1.34). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -1.34, *SD* = .764) and the 8th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = -1.21, *SD* = .738), *t*(61) = .678, *p* = .500].

Table 18

ELA Level 1 Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level Level 1	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	79	-.885	.700	1.37	156	.171	-.065	.360
	Non- Participating	79	-1.032	.649					
7th Grade	Participating	80	-.532	.813	.926	145	.356	-.161	.445
	Non-Participating	80	-.674						
8th Grade	Participating	32	-1.211	.738	.678	61	.500	-.250	.507
	Non-Participating	31	-1.334	.764					

The mean assessment score of the 6th-grade students (ELA FSA Level 2) whose teachers participated in the two professional development opportunities (M = -.273) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 2) whose teachers did not participate in the two professional development opportunities (M = -.455; Table 19). An independent sample t-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 2) of the non-participating teachers (M = -.455, SD = .771) and the 6th-grade students (ELA FSA Level 2) of the participating teachers [(M = -.273, SD = .736), $t(193) = 1.68$, $p = .095$]. The mean assessment score of the 7th-grade students (ELA FSA Level 2) whose teachers participated in the two professional development opportunities (M = .129) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 2) whose teachers did not participate in the two professional development opportunities (M = -.291). An independent sample t-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 2) of the non-participating teachers (M = -.291, SD = .992) and the 7th-grade students (ELA FSA Level 2) of the participating teachers [(M = .129, SD = .759), $t(164) = 3.06$, $p = .003$]. The mean assessment score of the 8th-grade students (ELA FSA Level 2) whose teachers did not participate in the two professional development opportunities (M = -.510) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 2) whose teachers participated in the two professional development opportunities (M = -.515). An independent sample t-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 2) of the non-participating teachers (*M* = -.510, *SD* = .746) and the 8th-grade students (ELA FSA Level 2) of the participating teachers [(*M* = -.515, *SD* = .691), *t*(82) = -.-032, *p* = .975].

Table 19

ELA Level 2 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level Level 2	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	98	-.273	.736	1.68	193	.095	-.032	.394
	Non- Participating	98	-.455	.772					
7th Grade	Participating	83	.127	.759	.926	145	.356	-.161	.446
	Non-Participating	83	-.291	.992					
8th Grade	Participating	42	-.515	.692	-.032	82	.975	-.317	.307
	Non-Participating	42	-.510	.746					

The mean assessment score of the 6th-grade students (ELA FSA Level 3) whose teachers participated in the two professional development opportunities (*M* = .287) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 3) whose teachers did not participate in the two professional development opportunities (*M* = .269; Table 20). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 3) of the non-participating teachers (*M* = .269, *SD* = .781) and the 6th-grade students (ELA FSA Level 3) of the participating teachers [(*M* = .287, *SD* = .772), *t*(204) = .160, *p* = .873]. The mean assessment score of the 7th-grade students (ELA FSA Level 3) whose teachers participated in the two professional development opportunities (*M* = .613) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 3) whose teachers did not participate in the two professional development opportunities (*M* = .060). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 3) of the non-participating teachers (*M* = -.060, *SD* = .778) and the 7th-grade students (ELA FSA Level 3) of the participating teachers [(*M* = .613, *SD* = .595), *t*(122) = 4.44, *p* = .000]. The mean assessment score of the 8th-grade students (ELA FSA Level 3) whose teachers did not participate in the two professional development opportunities (*M* = .331) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 3) whose teachers participated in the two professional development opportunities (*M* = .259). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 3) of the non-participating teachers (*M* =.331, *SD* = .501) and the 8th-grade students (ELA FSA Level 3) of the participating teachers [(*M* = .259, *SD* = .486), *t*(112) = -.780, *p* = .437].

Table 20

ELA Level 3 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level Level 3	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	103	.287	.772	.160	204	.873	-.198	.223
	Non- Participating	103	.269	.781					
7th Grade	Participating	62	.613	.595	4.44	122	.000	.307	.800
	Non-Participating	62	.060	.777					
8th Grade	Participating	57	.259	.486	-.780	112	.437	-.255	.111
	Non-Participating	57	.331	.501					

The mean assessment score of the 6th-grade students (ELA FSA Level 4) whose teachers did not participate in the two professional development opportunities (*M* = .809) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 4) whose teachers participated in the two professional development opportunities (*M* = .756; Table 21). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 4) of the non-participating teachers (*M* = .809, *SD* = .694) and the 6th-grade students (ELA FSA Level 4) of the participating teachers [(*M* = .756, *SD* = .734), *t*(24) = -.844, *p* = .641]. The mean assessment score of the 7th-grade students (ELA FSA Level 4) whose teachers participated in the two professional development opportunities (*M* = .869) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 4) whose teachers did not participate in the two professional development opportunities (*M* = .576). An independent sample *t*-test was performed and there was not a significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 4) of the non-participating teachers (*M* = .576, *SD* = .872) and the 7th-grade students (ELA FSA Level 4) of the participating teachers [(*M* = .869, *SD* = .638), *t*(78) = 1.80, *p* = .076]. The mean assessment score of the 8th-grade students (ELA FSA Level 4) whose teachers did not participate in the two professional development opportunities (*M* = .704) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 4) whose teachers participated in the two professional development opportunities (*M* = .700). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 4) of the non-participating teachers (*M* =.704, *SD* = .603) and the 8th-grade students (ELA FSA Level 4) of the participating teachers [(*M* = .700, *SD* = .630), *t*(72) = -.029, *p* = .977].

Table 21

ELA Level 4 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level Level 4	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	80	.756	.734	-.844	24	.641	-.274	.171
	Non- Participating	79	.809	.694					
7th Grade	Participating	44	.869	.637	1.80	86	.076	-.031	.617
	Non-Participating	44	.576	.872					
8th Grade	Participating	37	.700	.630	-.029	72	.977	-.290	.282
	Non-Participating	37	.704	.704					

The mean assessment score of the 6th-grade students (ELA FSA Level 5) whose teachers did not participate in the two professional development opportunities (*M* = 1.64) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 5) whose teachers participated in the two professional development opportunities (*M* = 1.45; Table 22). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 5) of the non-participating teachers (*M* = 1.64, *SD* = .472) and the 6th-grade students (ELA FSA Level 5) of the participating teachers [(*M* = 1.45, *SD* = .658), *t*(24) = -.844, *p* = .407]. The number of 7th grade students who scored a Level 5 on the FSA ELA Assessment was not large enough to perform an analysis. The mean assessment score of the 8th-grade students (ELA FSA Level 5) whose teachers did not participate in the two professional development opportunities (*M* = 1.56) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 5) whose teachers participated in the two professional development opportunities (*M* = 1.02). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 5) of the non-participating teachers (*M* =1.56, *SD* = .817) and the 8th-grade students (ELA FSA Level 5) of the participating teachers [(*M* = 1.02, *SD* = .611), *t*(26) = -1.96, *p* = .061].

Table 22

ELA Level 5 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in Two Professional Development Opportunities

Student Grade-level Level 5	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	13	1.45	.472	-.844	24	.407	-.653	.274
	Non- Participating	13	1.64	.658					
7th Grade	Participating	4	—	—	—	—	—	—	—
	Non-Participating	4	—	—	—	—	—	—	—
8th Grade	Participating	14	1.023	.611	-1.96	26	.060	-1.10	.025
	Non-Participating	14	1.559	.817					

Research Question 3: Teachers Who Attended One Professional Development Opportunity

The third research question compared the students' assessment scores of the teachers who attended one professional development opportunities and students' assessment scores of teachers who did not attend professional development opportunities.

The mean assessment score of the 6th-grade students whose teachers who did not participate in three professional development opportunities (*M* = .052) was higher than the mean assessment score of the 6th-grade students whose teachers did participate in three professional development opportunities (*M* = -.057; Table 23). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the students of the non-participating teachers (*M* = .052, *SD* = 1.01) and the students of the participating teachers [(*M* = -.057, *SD* = .992), *t*(634) = 1.32, *p* = .186]. The mean assessment score of the 7th-grade students whose teachers participated in the three professional development opportunities (*M* = .490) was higher than the mean assessment score of the 7th-grade students whose teachers did not participate in three professional development opportunities (*M* = -.505). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the students of the non-participating teachers (*M* = -.505, *SD* = .738) and the students of the participating teachers [(*M* = .490, *SD* = .979), *t*(232) = 10.7, p = .000]. The mean assessment score of the 8th-grade students whose teachers who did not participate in three professional development opportunities (*M* = .012) was higher than the mean assessment score of the 8th-grade students whose teachers did participate in three professional development opportunities (*M* = -.012). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the students of the non-participating teachers (*M* = -.102, *SD* = 1.01) and the students of participating teachers [(*M* = -.012, *SD* = .985), *t*(1141) = -.407, p = .684].

Table 23

Student Assessment Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th grade	Participating	54	.543	.738	6.702	106	.000	.765	1.41
	Non- Participating	54	-.543	.935					
7th grade	Participating	201	.138	.943	2.77	402	.374	.079	.467
	Non-Participating	203	-.136	1.03					
8th grade									
	Participating	380	-.034	.997	-.964	749	.335	-.214	.073
	Non-Participating	371	.036	1.00					

Subgroup data: ELL, ESE, Free and Reduced Lunch, Achievement Levels for Teachers who attended one Professional Development Opportunities

The number of 6th-grade ELL students whose teachers participated in one professional development opportunity was insufficient for analysis. The mean assessment score of the 7th-grade ELL students whose teachers did not participate in one professional development opportunity (*M* = -.837) was higher than the mean assessment score of the 7th-grade ELL students whose teachers participated in one professional development opportunity (*M* = -.899; Table 24). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 7th-grade ELL students of the non-participating teachers (*M* = -.837, *SD* = 1.28) and the 7th-grade ELL students of the participating teachers [(*M* = -.899, *SD* = .732), *t*(23) = .154, *p* = .879]. The mean assessment score of the 8th-grade ELL students whose teachers who did not participate in one professional development opportunity (*M* = -.597) was higher than the mean assessment score of the 8th-grade ELL students whose teachers participated in one professional development opportunity (*M* = -.922). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade ELL students of the non-participating teachers (*M* = -.597, *SD* = .974) and the 8th-grade ELL students of the participating teachers [(*M* = - .922, *SD* = .1.09), *t*(40) = -1.20, *p* = .235].

Table 24

ELL Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level ELL	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	3	—	—	—	—	—	—	—
	Non- Participating	6	—	—	—	—	—	—	—
7th Grade	Participating	15	-.899	.732	-.154	23	.879	-.892	.769
	Non-Participating	10	-.837						
8th Grade	Participating	40	-.922	1.09	-1.20	48	.235	-.867	.218
	Non-Participating	22	-.597	.974					

The mean assessment score of the 6th-grade SWD students whose teachers who participated in the one professional development opportunity (*M* = .162) was higher than the mean assessment score of the 6th-grade SWD students whose teachers did not participate in one professional development opportunity (*M* = -1.15; Table 25). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 6th-grade SWD students of the non-participating teachers (*M* = -1.15, *SD* = .816) and the 6th-grade SWD students of the participating teachers [(*M* = .162, *SD* = .541, *t*(77) = 5.51, *p* = .000]. The mean assessment score of the 7th-grade SWD students whose teachers participated in one professional development opportunity (*M* = -.561) was higher than the mean assessment score of the 7th-grade SWD students whose teachers did not participate in one professional development opportunity (*M* = -.617). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 7th-grade SWD students of the non-participating teachers (*M* = -.617, *SD* = .832) and the 7th-grade SWD students of the participating teachers [(*M* = -.561, *SD* = .804), *t*(27) = .84, *p* = .855]. The mean assessment score of the 8th-grade SWD students whose teachers who did participate in one professional development opportunity (*M* = -1.11) was higher than the mean assessment score of the 8th-grade SWD students whose teachers did not participate in one professional development opportunity (*M* = -1.12). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade SWD students of the non-participating teachers (*M* = -1.12, *SD* = 1.01) and the 8th-grade SWD students of the participating teachers [(*M* = -1 .11, *SD* = 1.11), *t*(64) = -.014, *p* = .989].

Table 25

SWD Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level SWD	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	15	.162	.816	5.51	77	.000	.652	1.39
	Non- Participating	14	-1.15	.541					
7th Grade	Participating	16	-.561	.804	5.13	24	.856	.785	1.84
	Non-Participating	13	-.617	.832					
8th Grade	Participating	36	-1.12	1.11	-.014	64	.989	-.530	.523
	Non-Participating	30	-1.11	1.01					

The mean assessment score of the 6th-grade students (free or reduced lunch) whose teachers who participated in one professional development opportunity (M = .482) was higher than the mean assessment score of the 6th-grade students (free or reduced lunch) whose teachers did not participate in one professional development opportunity (M = -.740; Table 26). An independent sample t-test was performed and there was a significant difference between the mean assessment scores of the 6th-grade students (free or reduced lunch) of the non-participating teachers (M = -.740, SD = .821) and the 6th-grade students (free or reduced lunch) of the participating teachers [(M = .482, SD = .737), $t(73)$ = 6.782, p = .000]. The mean assessment score of the 7th-grade students (free or reduced lunch) whose teachers participated in one professional development opportunity (M = -.031) was higher than the mean assessment score of the 7th-grade students (free or reduced lunch) whose teachers did not participate in the three professional development opportunities (M = -.150). An independent sample t-test was performed and there was not a significant difference between the mean assessment scores of the 7th-grade students (free or reduced lunch) of the non-participating teachers (M = -.150, SD = 1.10) and the 7th-grade students (free or reduced lunch) of the participating teachers [(M = -.031, SD = .963), $t(236)$ = .883, p = .378]. The mean assessment score of the 8th-grade students (free or reduced lunch) whose teachers who participated in one professional development opportunity (M = .425) was higher than the mean assessment score of the 8th-grade students (free or reduced lunch) whose teachers did not participate in the three professional development opportunities (M = -.019). An independent sample t-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (free or reduced lunch) of the non-participating teachers (*M* = -.019, *SD* = 1.03) and the 8th-grade students (free or reduced lunch) of the participating teachers [(*M* = .425, *SD* = .841), *t*(186) = -2.74, *p* = .007].

Table 26

FRL Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level FRL	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	38	.482	.737	6.78	73	.000	.823	1.58
	Non- Participating	37	-.740	.822					
7th Grade	Participating	111	-.031	.963	.883	236	.378	-.147	3.86
	Non-Participating	127	-.150	1.10					
8th Grade	Participating	51	.425	.841	2.74	186	.003	.124	.763
	Non-Participating	137	-.0187	1.034					

The mean assessment score of the 6th-grade students (ELA FSA Level 1) whose teachers participated in one professional development opportunity (*M* = .279) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 1) whose teachers did not participate in one professional development opportunity (*M* = -1.05; Table 27). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -1.05, *SD* = .614) and the 6th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = .279, *SD* = .720), *t*(54) = 7.44, *p* = .000]. The mean assessment score of the 7th-grade students (ELA FSA Level 1) whose teachers participated in one professional development opportunity (*M* = -.677) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 1) whose teachers did not participate in one professional development opportunity (*M* = -.859).

An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -.859, *SD* = .774) and the 7th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = .677, *SD* = .789), *t*(96) = 1.51, *p* = .252]. The mean assessment score of the 8th-grade students (ELA FSA Level 1) whose teachers did not participate in one professional development opportunity (*M* = -1.18) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 1) whose teachers participated in one professional development opportunity (*M* = -1.23). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 1) of the non-participating teachers (*M* = -1.17, *SD* = .934) and the 8th-grade students (ELA FSA Level 1) of the participating teachers [(*M* = -1.23, *SD* = .877), *t*(153) = -.340, *p* = .734].

Table 27

ELA Level 1 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level Level 1	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	28	.279	.720	7.44	54	.000	.973	1.69
	Non- Participating	28	-1.05	.614					
7th Grade	Participating	49	-.677	.789	1.15	96	.252	-.132	.496
	Non-Participating	49	-.859	.775					
8th Grade	Participating	78	-1.22	.877	-.340	153	.734	-.337	.238
	Non-Participating	77	-1.18	.934					

The mean assessment score of the 6th-grade students (ELA FSA Level 2) whose teachers participated in one professional development opportunity (*M* = .491) was higher than the mean assessment score of the 6th-grade students (ELA FSA Level 2) whose teachers did not participate in one professional development opportunity (*M* = -.381; Table 28). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 6th-grade students (ELA FSA Level 2) of the non-participating teachers (*M* = -.381, *SD* = .967) and the 6th-grade students (ELA FSA Level 2) of the participating teachers [(*M* = .491, *SD* = .596), $t(26) = 2.87$, $p = .008$]. The mean assessment score of the 7th-grade students (ELA FSA Level 2) whose teachers participated in one professional development opportunity (*M* = -.013) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 2) whose teachers did not participate in one professional development opportunity (*M* = -.364). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 2) of the non-participating teachers (*M* = -.364, *SD* = .934) and the 7th-grade students (ELA FSA Level 2) of the participating teachers [(*M* = -.013, *SD* = .877), $t(153) = .340$, $p = .734$]. The mean assessment score of the 8th-grade students (ELA FSA Level 2) whose teachers did not participate in one professional development opportunity (*M* =-.197) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 2) whose teachers participated in one professional development opportunity (*M* = -.398). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 2) of the non-participating teachers (*M* = -.197, *SD* = .715) and the 8th-grade students (ELA FSA Level 2) of the participating teachers [(*M* = -.398, *SD* = .558), $t(156) = -1.97$, $p = .051$].

Table 28

ELA Level 2 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development

Student Grade-level Level 2	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade									
	Participating	14	.491	.596	2.89	26	.008	.248	1.15
	Non- Participating	14	-.381	.561					
7th Grade									
	Participating	66	-.013	.782	2.29	128	.024	.047	.653
	Non-Participating	64	-.364	.956					
8th Grade									
	Participating	79	-.398	.558	-1.97	156	.051	-.402	.001
	Non-Participating	79	-.197	.715					

The number of 6th-grade students (ELA FSA Level 3) whose teachers participated in one professional development opportunity was insufficient for analysis. The mean assessment score of the 7th-grade students (ELA FSA Level 3) whose teachers participated in one professional development opportunity (*M* = .570) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 3) whose teachers did not participate in one professional development opportunity (*M* = .153; Table 29). An independent sample *t*-test was performed and there was a significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 3) of the non-participating teachers (*M* = .153, *SD* = .799) and the 7th-grade students (ELA FSA Level 3) of the participating teachers [(*M* = .570, *SD* = .711), $t(88) = 2.61$, $p = .011$]. The mean assessment score of the 8th-grade students (ELA FSA Level 3) whose teachers participated in one professional development opportunity (*M* = .307) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 3) whose teachers did not participate in one professional development opportunity (*M* = .285). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 3) of the non-participating teachers (*M* = .285, *SD* = .571) and the 8th-grade students (ELA FSA Level 3) of the participating teachers [(*M* = .307, *SD* = .654), *t*(246) = .287, *p* = .774].

Table 29

ELA Level 3 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level Level 3	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	9	—	—	—	—	—	—	—
	Non-Participating	9	—	—	—	—	—	—	—
7th Grade	Participating	45	.570	.711	2.62	88	.011	.100	.734
	Non-Participating	45	.153	.799					
8th Grade	Participating	124	.307	.653	.287	246	.774	-.131	.176
	Non-Participating	124	.290	.571					

The number of 6th-grade students (ELA FSA Level 4) whose teachers participated in one professional development opportunity was insufficient for analysis. The mean assessment score of the 7th-grade students (ELA FSA Level 4) whose teachers participated in one professional development opportunity (*M* = .791) was higher than the mean assessment score of the 7th-grade students (ELA FSA Level 4) whose teachers did not participate in one professional development opportunity (*M* = .581; Table 30). An independent sample *t*-test was performed and there was not a significant difference between the mean assessment scores of the 7th-grade students (ELA FSA Level 4) of the non-participating teachers (*M* = .584, *SD* = .892) and the 7th-grade students (ELA FSA Level 4) of the participating teachers [(*M* = .791, *SD* = .743), *t*(68) = 1.05, *p* = .296]. The mean assessment score of the 8th-grade students (ELA FSA Level 4) whose teachers did not participate in one professional development opportunity (*M* = .804) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 4) whose teachers participated in one professional development opportunity (*M* = .767). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 4) of the non-participating teachers (*M* = .804, *SD* = .448) and the 8th-grade students (ELA FSA Level 4) of the participating teachers [(*M* = .767, *SD* = .537), *t*(147) = .449, *p* = .654].

Table 30

ELA Level 4 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level Level 4	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	3	—	—	—	—	—	—	—
	Non- Participating	3	—	—			—		
7th Grade	Participating	35	.791	.743	1.05	68	.296	.010	.734
	Non-Participating	35	.584	.892					
8th Grade	Participating	75	.767	.537	-.449	147	.654	-.197	.124
	Non-Participating	74	.804	.448					

The number of 6th-grade and 7th-grade students (ELA FSA Level 5) whose teachers participated in one professional development opportunity was insufficient for analysis. The mean assessment score of the 8th-grade students (ELA FSA Level 4) whose teachers did not participate in one professional development opportunity (*M* = 1.44) was higher than the mean assessment score of the 8th-grade students (ELA FSA Level 5) whose teachers participated in one professional development opportunity (*M* = 1.17; Table 31). An independent sample *t*-test was performed and there was no significant difference between the mean assessment scores of the 8th-grade students (ELA FSA Level 5) of the non-participating teachers (*M* = 1.44, *SD* = .751) and the 8th-grade students (ELA FSA Level 5) of the participating teachers [(*M* = 1.17, *SD* = .546), *t*(32) = -1.20, *p* = .238].

Table 31

ELA Level 5 Student Scores: Results Including Means and Significance of T-test for Teachers Participating in One Professional Development Opportunity

Student Grade-level Level 5	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th Grade	Participating	0	—	—	—	—	—	—	—
	Non- Participating	0	—	—			—		
7th Grade	Participating	6	—	—	—	—	—	—	—
	Non-Participating	6	—	—			—		
8th Grade	Participating	17	1.17	.546	-1.20	32	.238	-.730	.188
	Non-Participating	17	1.44	.751					

Additional Analysis

Data was gathered from the 2014-2015 school year for the Central Florida school district science scores on end-of-year assessments and the state science test. The same procedure was followed to propensity score match students based on ELA FSA prior year scores. The data were used as a baseline for participants whose mean scores were higher than the non-participants, and a *t*-test was performed to indicate significance between the means.

Prior to the start of this study, the mean assessment score of the 7th-grade students whose teachers participated in three professional development opportunities (*M* = .153) was higher than the mean assessment score of the 7th-grade students whose teachers did not participate in three professional development opportunities (*M* = -.154; Table 32). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment score of the 7th-grade students of the non-participating teachers (*M* = -.154, *SD*=1.02) and the 7th-grade students of the participating teachers [(*M* = .153, *SD* = .955), *t*(539) = 3.61, *p* = .000].

Table 32

7th Grade Student Assessment Scores: Baseline Results Including Means and Significance for T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	272	.153	.955	3.61	539	.000	.139	.470
	Non-Participating	269	-.154	1.02					

Prior to the start of this study, the mean assessment score of the 7th-grade students (ELL) whose teachers participated in three professional development opportunities (*M* = -.391) was higher than the mean assessment score of the 7th-grade students (ELL) whose teachers did not participate in three professional development opportunities (*M* = -1.01; Table 33). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (ELL) of the non-participating teachers (*M* = -1.01, *SD*=.683) and the 7th-grade students (ELL) of the participating teachers [(*M* = -.391, *SD* = .901), *t*(75) = 3.46, *p* = .001].

Table 33

7th Grade ELL Student Scores: Baseline Results Including Means and Significance for T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	31	-.391	.901	3.46	75	.001	.181	.264
	Non-Participating	46	-1.01	.683					

Prior to the start of this study, the mean assessment score of the 7th-grade students (free and reduced lunch) whose teachers participated in three professional development opportunities (*M* = .017) was higher than the mean assessment score of the 7th-grade students (free and reduced lunch) whose teachers did not participate in three professional development opportunities (*M* = -.376; Table 34). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (free and reduced lunch) of the non-participating teachers (*M* = -.376, *SD*=.940) and the 7th-grade students (free and reduced lunch) of the participating teachers [(*M* = -.376, *SD* = .951), *t*(355) = 3.92, *p* = .000].

Table 34

7th Grade FRL Student Scores: Baseline Results Including Means and Significance for T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	184	.017	.940	3.92	355	.000	.196	.590
	Non-Participating	173	-.376	.951					

Prior to the start of this study, the mean assessment score of the 7th-grade students (FSA ELA 1) whose teachers participated in three professional development opportunities (*M* = -.548) was higher than the mean assessment score of the 7th-grade students (FSA ELA 1) whose teachers did not participate in three professional development opportunities (*M* = -.904; Table 35). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (FSA ELA 1) of the non-participating teachers (*M* = -.904, *SD*=.806) and the 7th-grade students (FSA ELA 1) of the participating teachers [(*M* = -.548, *SD* = .840), *t*(187) = 2.98, *p* = .003].

Table 35

7th Grade ELA Level 1 Student Scores: Baseline Results Including Means and Significance for T-test for Teachers Participating in Three Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	94	-.548	.840	2.98	187	.003	.120	.592
	Non-Participating	95	-.904	.806					

Prior to the start of this study, the mean assessment score of the 7th-grade students (FSA ELA 2) whose teachers participated in three professional development opportunities (*M* = .025) was higher than the mean assessment score of the 7th-grade students (FSA ELA 2) whose teachers did not participate in three professional development opportunities (*M* = -.330; Table 36). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (FSA ELA 2) of the non-participating teachers (*M* = -.330, *SD*=.695) and the 7th-grade students (FSA ELA 2) of the participating teachers [(*M* = .025, *SD* = .786), *t*(114) = 2.59, *p* = .011].

Table 36

FSA ELA Level 2 Student Scores: Baselines Results Including Means and Significance of T-test for 7th-Grade Teachers in Three Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	56	.025	.786	2.59	114	.011	.083	.628
	Non-Participating	60	-.330	.695					

Prior to the start of this study, the mean assessment score of the 7th-grade students whose teachers participated in two professional development opportunities (*M* = .139) was higher than the mean assessment score of the 7th-grade students whose teachers did not participate in two professional development opportunities (*M* = -.141; Table 37). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment score of the 7th-grade students of the non-participating teachers (*M* = -.141, *SD*=1.02) and the 7th-grade students of the participating teachers [(*M* = .139, *SD* = .961), *t*(331) = 2.58, *p* = .010].

Table 37

Baseline Results Including Means and Significance of T-test for 7th-Grade Teachers Participating in Two Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	168	.139	.961	2.58	331	.010	.066	.494
	Non-Participating	165	-.141	1.02					

Prior to the start of this study, the mean assessment score of the 7th-grade students (free and reduced lunch) whose teachers participated in two professional development opportunities (M = .057) was higher than the mean assessment score of the 7th-grade students (free and reduced lunch) whose teachers did not participate in two professional development opportunities (M = -.276; Table 38). An independent sample t-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (free and reduced lunch) of the non-participating teachers (M = -.276, SD = .980) and the 7th-grade students (free and reduced lunch) of the participating teachers [(M = .057, SD = .888), $t(184)$ = 2.43, p = .016].

Table 38

FRL Student Scores: Baseline Results Including Means and Significance of T-test for 7th-Grade Teachers Participating in Two Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	86	.057	.888	2.43	183	.016	.137	.062
	Non-Participating	99	-.276	.980					

Prior to the start of this study, the mean assessment score of the 7th-grade students (FSA ELA 3) whose teachers participated in two professional development opportunities (*M* = .351) was higher than the mean assessment score of the 7th-grade students (FSA ELA 3) whose teachers did not participate in two professional development opportunities (*M* = .072; Table 39). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (FSA ELA 3) of the non-participating teachers (*M* = .072, *SD*=.792) and the 7th-grade students (FSA ELA 3) of the participating teachers [(*M* = .351, *SD* = .667), *t*(97) = 1.90, *p* = .062].

Table 39

FSA ELA Level 3 Student Scores: Baseline Results Including Means and Significance of T-test for 7th-Grade Teachers Participating in Two Professional Development Opportunities

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
7th grade	Participating	50	.351	.667	1.90	97	.062	-.013	.572
	Non-Participating	49	.072	.792					

Prior to the start of this study, the mean assessment score of the 8th-grade students (free and reduced lunch) whose teachers did not participate in one professional development opportunity (*M* = -.031) was higher than the mean assessment score of the 8th-grade students (free and reduced lunch) whose teachers participated in one professional development opportunities (*M* = -.063; Table 40). An independent sample *t*-test was performed and there was no significant difference between the pre-study mean assessment scores of the 8th-grade students (free and reduced lunch) of the non-participating teachers (*M* = -.031, *SD* = .992) and the 8th-grade students (free and reduced lunch) of the participating teachers [(*M* = -.063, *SD* = 1.03), *t*(453) = -.382, *p* = .702].

Table 40

FRL Student Scores: Baseline Results Including Means and Significance of T-test for 8th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
8th grade	Participating	247	-.063	1.03	-.382	453	.702	-.224	.151
	Non-Participating	208	-.031	.992					

Prior to the start of this study, the mean assessment score of the 7th-grade students (FSA ELA 2) whose teachers participated in one professional development opportunity (*M* = -.228) was higher than the mean assessment score of the 7th-grade students (FSA ELA 2) whose teachers did not participate in one professional development opportunity (*M* = -.567; Table 41). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (FSA ELA 2) of the non-participating teachers (*M* = -.567, *SD*=.769) and the 7th-grade students (FSA ELA 2) of the participating teachers [(*M* = -.228, *SD* = .701), *t*(128) = 2.26, *p* = .010].

Table 41

FSA Level 2 Student Scores: Baseline Results Including Means and Significance of T-test for 7th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
8th grade	Participating	65	-.228	.701	2.26	128	.010	.084	.595
	Non-Participating	65	-.567	.769					

Prior to the start of this study, the mean assessment score of the 7th-grade students (FSA ELA 3) whose teachers participated in one professional development opportunity (*M* = .325) was higher than the mean assessment score of the 7th-grade students (FSA ELA 3) whose teachers did not participate in one professional development opportunity (*M* =-.104; Table 42). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 7th-grade students (FSA ELA 3) of the non-participating teachers (*M* = -.104, *SD*=.676) and the 7th-grade students (FSA ELA 3) of the participating teachers [(*M* = .325, *SD* = .769), *t*(252) = 4.74, *p* = .000].

Table 42

FSA Level 3 Student Scores: Baseline Results Including Means and Significance of T-test for 7th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CUL
7th grade	Participating	127	.325	.676	4.74	252	.000	.252	.609
	Non-Participating	127	-.104	.769					

Prior to the start of this study, the mean assessment score of the 6th-grade students whose teachers participated in one professional development opportunity (*M* = .199) was higher than the mean assessment score of the 6th-grade students whose teachers did not participate in one professional development opportunity (*M* = -.201; Table 43). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment score of the 6th-grade students of the non-participating teachers (*M* = -.201, *SD*=.930) and the 6th-grade students of the participating teachers [(*M* = .199, *SD* = .9930), *t*(386) = 4.02, *p* = .000].

Table 43

Baseline Results Including Means and Significance of T-test for 6th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th grade	Participating	195	.199	.930	4.02	386	.000	.205	.567
	Non-Participating	193	-.201	1.03					

Prior to the start of this study, the mean assessment score of the 6th-grade students (SWD) whose teachers participated in one professional development opportunity (*M* = -.371) was higher than the mean assessment score of the 6th-grade students (SWD) whose teachers did not participate in one professional development opportunity (*M* = -1.03; Table 44). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 6th-grade students (SWD) of the non-participating teachers (*M* = -1.03, *SD*=.686) and the 6th-grade students (SWD) of the participating teachers [(*M* = -.571, *SD* = .970), *t*(39) = 2.33, *p* = .025].

Table 44

SWD Student Scores: Baseline Results Including Means and Significance of T-test for 6th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th grade	Participating	26	-.371	.970	2.33	39	.025	.087	1.24
	Non-Participating	15	-1.03	.686					

Prior to the start of this study, the mean assessment score of the 6th-grade students (free and reduced lunch) whose teachers participated in one professional development opportunity (*M* = -.103) was higher than the mean assessment score of the 6th-grade students (free and reduced lunch) whose teachers did not participate in one professional development opportunities (*M* = -.3963; Table 45). An independent sample *t*-test was performed and there was no significant difference between the pre-study mean assessment scores of the 6th-grade students (free and reduced lunch) of the non-participating teachers (*M* = -.396, *SD* = .978) and the 6th-grade students (free and reduced lunch) of the participating teachers [(*M* = -.103, *SD* = .900), *t*(225) = 2.33, *p* = .021].

Table 45

FRL Student Scores: Baseline Results Including Means and Significance of T-test for 6th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th grade	Participating	104	-.103	.900	2.33	225	.021	.045	.540
	Non-Participating	123	-.396	.978					

Prior to the start of this study, the mean assessment score of the 6th-grade students (FSA ELA 1) whose teachers participated in one professional development opportunity (*M* = -.595) was higher than the mean assessment score of the 6th-grade students (FSA ELA 1) whose teachers did not participate in one professional development opportunity (*M* = -1.28; Table 46). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 6th-grade students (FSA ELA 1) of the non-participating teachers (*M* = -1.28, *SD*=.545) and the 6th-grade students (FSA ELA 1) of the participating teachers [(*M* = -.595, *SD* = .752), *t*(106) = 5.447, *p* = .000].

Table 46

FSA Level 1 Student Scores: Baseline Results Including Means and Significance of T-test for 6th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th grade	Participating	54	-.595	.752	5.45	106	.000	.438	.939
	Non-Participating	54	-1.28	.545					

Prior to the start of this study, the mean assessment score of the 6th-grade students (FSA ELA 2) whose teachers participated in one professional development opportunity (*M* = .051) was higher than the mean assessment score of the 6th-grade students (FSA ELA 2) whose teachers did not participate in one professional development opportunity (*M* = -.432; Table 47). An independent sample *t*-test was performed and there was a significant difference between the pre-study mean assessment scores of the 6th-grade students (FSA ELA 2) of the non-participating teachers (*M* = -.432, *SD*=.608) and the 6th-grade students (FSA ELA 2) of the participating teachers [(*M* = -.051, *SD* = .667), *t*(100) = 3.82, *p* = .000].

Table 47

FSA Level 2 Student Scores: Baseline Results Including Means and Significance of T-test for 6th-Grade Teachers Participating in One Professional Development Opportunity

Student Grade-level	Teacher Participation	*N*	*M*	*SD*	*t*	*df*	*p*	CIL	CIU
6th grade	Participating	51	.051	.667	3.82	100	.000	.231	.733
	Non-Participating	51	-.432	.608					

Summary

In this chapter, data were gathered regarding the mean scores for students whose teachers participated in three, two, and one professional development opportunity and the mean scores of students whose teachers who did not. The students' scores were propensity matched based on student reading level on FSA ELA assessment. The students' scores were converted to *z*-scores for normalization, and then a *t*-test was performed in SPSS version 24, 2016 to determine if there was significance between the means difference.

Overall, the student scores for the following groups were higher for the teachers who participated in professional development opportunities and the means differences were significant with 95% confidence (Table 48). The null hypotheses were accepted if the difference between the means were not greater for the teachers participating in one, two, or three professional development opportunities with 95% confidence.

Table 48

Overall Results of T-test

Professional Developments Groups	Results
Teachers who attended 3 professional development opportunities	The null hypothesis is rejected for overall 7th grade students, *p*=.000, but accepted for 6th grade overall and 8th grade overall
Teachers who attended 2 professional development opportunities	The null hypothesis is rejected for 7th grade overall, *p*=.000, but accepted for 6th grade overall and 8th grade overall
Teachers who attended 1 professional development opportunities	The null hypothesis is rejected for 6th grade overall, *p*=.000, but accepted for 7th grade overall and 8th grade overall

Prior year data was gathered to determine if there were differences between mean student scores before the teachers attended the professional development opportunities. The differences in means scores for 8th-grade students who received free and reduced lunch were not significant for the prior year. The differences in mean scores for 7th grade students who scored a level 3 on FSA ELA were not significant for the prior year. These two groups were the only prior year changes. These results will be discussed in Chapter 5.

CHAPTER 5
DISCUSSION AND CONCLUSION

Introduction

This chapter provides an overview of the purpose statement, methodology, and data analysis. In addition, this chapter includes a summary of the findings and a discussion of the finding related to teacher attendance at on-going professional development opportunities. Additionally, conclusions are drawn, recommendations made, implications to practice explored, and recommendations suggested for future studies are discussed in this chapter.

Purpose Statement

The study was conducted to determine if ongoing professional development in pedagogical strategies, collaboration strategies, and science content knowledge impacted student achievement as evidenced by a rise in science scores. Increased achievement was measured using scale scores on the school district end-of-year examinations or the statewide science assessment. The researcher examined the impact professional development in the area of science content, pedagogy, and professional learning communities had on student achievement.

Methodology

Middle school science teachers in a central Florida school district had an opportunity to participate in up to three on-going professional development opportunities through a Math Science Partnership Grant. The study was quantitative, gathering student scale scores on the statewide science assessment, the 6th-grade Life Science end-of-year assessment, or the 7th-grade Earth Science Space Science end-of-year assessment. The data was de-identified and included the following demographic information about the students who took the exams: (a) ELL status, (b) disability status, (c) free and reduced lunch status, and (e) levels of achievement on the Florida Standards Assessment for ELA. The students whose teachers participated in professional development opportunities were propensity scored matched to the students whose teachers did not participate in professional development opportunities based on FSA ELA achievement level. The scale scores were covered to *z*-scores for normalization.

Data Analysis

The scale scores gathered from the selected assessments and the scale scores from each of the assessments were converted into z scores. The scores were analyzed for statistical significance to determine if the number of professional development opportunities that middle school science teachers in a central Florida school district chose to attend impacted student achievement as measured by students' standardized assessments in relation to teachers who did not attend the professional development opportunities.

Summary and Discussion of Findings

Question 1

What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participated in three on-going professional development opportunities and the students whose teachers did not participant three professional development opportunities throughout the 2015-16 school year?

The findings indicate that the mean scores were higher for students whose teachers did not participate in three professional developments opportunities in the following grades:

- Overall results—6th and 8th grades,
- Students with disabilities—6th and 8th grades,
- Students receiving free and reduced lunch—6th and 8th grades,
- Students scoring a Level 1 on FSA ELA—6th grade,
- Students scoring a Level 2 on FSA ELA—6th and 8th grades,
- students scoring a Level 3 on FSA ELA—6th and 8th grades,
- students scoring a Level 4 on FSA ELA—6th grade, and
- students scoring a Level 5 on FSA ELA—8th grade.

The mean scores were higher but without significance for students (ELL) whose teachers participated in three professional development opportunities in the following grades:

- Overall results—6th and 8th grades,
- Students with disabilities—7th grade,
- Students scoring a Level 1 on FSA ELA assessment —8th grade,
- Students scoring a Level 3 on FSA ELA assessment—7th grade, and
- Students scoring a Level 4 on FSA ELA assessment—8th grade.

The mean scores of students whose teachers participated in three on-going professional development opportunities were higher, with significance, than the mean scores of students whose teachers who did not participate in three on-going professional development opportunities in the following grades:

Overall results—7th grade,

English language learners (ELL students)—7th grade,

Students receiving free and reduced lunch—7th grade, and

Students scoring a Level 1 or 2 on FSA ELA—7th grade.

Additional analysis was performed on prior year data that show that the mean scores for the 7th-grade students for the categories listed (ELL, free and reduced lunch, Level 1 and 2 on FSA ELA) was higher than other students prior to teachers participating in three professional development opportunities. The difference in mean scores is significant for the prior year. Before the implementation of the study, the mean scores of the students whose teachers agreed to participate in three professional development opportunities were already significantly higher, for the prior year and the current year, than the mean scores of the students whose teachers did not agree to participate in three on-going professional development opportunities.

The findings also indicate that the means scores of students whose teachers participated in three on-going professional development opportunities were not significantly higher than the mean scores of students whose teachers who did not participate in three on-going professional development opportunities; the teachers whose students' mean scores were significantly higher after they attended three professional development opportunities had higher student mean scores the previous year.

One factor that may have contributed to the lack of significance in the difference in mean scores between the teachers who participated in three ongoing professional developments opportunities and the teachers who did participate in three ongoing professional development opportunities was the time between the professional development activities and the collection of the data. Research indicates that teachers need time to change beliefs (Chval et al., 2008), time to implement changes in the classroom (Asseri, 2015), and time to internalize new ideas, new skills, and to reflect on learning (Eun, 2008).

Other factors that impact teachers' implementation of professional development strategies include (a) support from administrators (Lewis et al., 2015), (b) student characteristics, (c) classroom characteristics, and (b) school district characteristics (Desimone, 2009). Reading level is a student characteristic that also qualifies a barrier to student improvement on the assessment instruments. Based on the high correlation between the FSA ELA assessment and the standardized science assessments used in data collection, the student reading level could impact students score even if the teacher implemented the strategies promoted by the professional development opportunities. These factors can hinder teachers' full implementation of the strategies learned during participation in the professional development opportunities.

Barriers to implementation skills, knowledge, and strategies included in the science professional development opportunity is the difficulty of implementing inquiry-based learning in the classroom without support (Nam et al., 2014). The teachers may not have had a full understanding of how to implement inquiry in the classroom. Teachers may be comfortable implementing the professional development strategies, but the strategies are not measures on the standardized assessments used for measurement.

Based on certification, teachers may have implemented the professional development strategies but may still need additional professional development to fill in gaps in pedagogy or science content knowledge in comparison to other teachers.

Question 2

What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments whose middle school science teachers participated in two on-going professional development opportunities and the students whose teachers did not participate in two professional development opportunities throughout the 2015-16 school year?

The findings show that the mean scores were higher for students whose teachers did not participate in two professional development opportunities in the following grades:

- Overall results—8th grade,
- English language learners (ELL) students—8th grade,
- Students with disabilities—6th and 8th grades,
- Students who receive free and reduced lunch—8th grade,
- Students scoring a Level 2 on FSA ELA—8th grade,
- Students scoring a Level 3 on FSA ELA—6th grade,
- Students scoring a Level 4 on FSA ELA—6th and 8th grades, and
- Students scoring a Level 5 on FSA ELA—6th and 8th grade.

The mean scores were higher but without significance for students whose teachers attended two professional development opportunities in the following grades:

Overall results—6th grade,

English language learners (students) —6th and 7th grades,

Students with disabilities—7th grade,

Students receiving free or reduced lunch—6th grade,

Students scoring a Level 1 on FSA ELA—6th,, 7th, and 8th grades,

Students scoring a Level 2 on FSA ELA—6th and 7th grades,

Students scoring a Level 3 on FSA ELA—8th grade, and

Students scoring a Level 4 on FSA ELA—7th grade.

The mean scores of students whose teachers participated in two professional development opportunities were higher, with significance, than the means scores of students whose teachers did not participate in two professional development opportunities in the following grades:

Overall results—7th grade,

Students receiving free and reduced lunch—7th grade, and

Students scoring a Level 3 on FSA ELA assessment—7th grade.

Additional analysis performed on prior year data that show that the means scores for the 7th-grade students for the categories listed (receiving free and reduced lunch and Level 3 and FSA ELA) were not significantly higher the prior year for 7th grade FSA ELA Level 3 students but were significantly higher for 7th grade overall and 7th grade students who receive free and reduced lunch.

Prior research indicates that support from administrators and other teachers, along with PLC attitudes, can impact implementation of professional development. In the 2014-2015 and 2015-2016 school years overall, the findings also indicate that the mean scores of students whose teachers attended two professional development opportunities were higher, with significance, thank the scores of students who did not attend two professional development opportunities. The mean scores of students scoring a Level 3 on the FSA ELA were also significantly higher than the mean scores of students whose teachers did not attend two professional development opportunities, which differed from the 2014-15 school year. Professional development strategies could have been impacted specific sub groups to increase the student achievement (Bianchini & Cavazon, 2006).

Research indicates there are multiple barriers to accessing professional development opportunities that translate into higher student achievement, which could have prevented students from showing a significantly higher mean score. The time needed to implement new strategies (Aseeri, 2015), the time needed to change beliefs (Chval et al., 2008), and time to internalize professional development or reflect on the learning provided by the professional development may have been lacking (Eun, 2008). Other barriers that could impact the implementation of the professional development strategies and impact students' test scores include the following: (a) the lack of understanding of implementing a lesson based in inquiry and constructivism (Arce et al., 2014) and (b) difficulty in measuring the amount of teacher learning at professional development opportunities (Lewis et al., 2015).

Based on teacher certification, the two professional development opportunities may not have provided enough of a learning opportunity to bridge the gaps in pedagogy and science content knowledge to impact student assessment scores in comparison to other teachers.

Question 3

What differences exist between student achievement scale scores on the state science assessment or district end-of-year science assessments of students whose middle school science teachers participates in one on-going professional development opportunity and those students whose teachers did not participate in one or less professional development opportunity throughout the 2015-16 school year?

The findings showed that the mean scores were higher for students whose teacher did not participate in one professional development opportunity in the following grades:

- Overall results—8th grade,

- English language learners (ELL) students—6th and 7th grades,
- Students with disabilities—8th grade,
- Students scoring a Level 1 on FSA ELA—8th grade,
- Students scoring a Level 2 on FSA ELA—8th grade,
- Students scoring a Level 4 on FSA ELA—8th grade, and
- Students scoring a Level 5 on FSA ELA—8th grade.

The mean scores were higher but without significance for students whose teachers attended one professional development opportunity in the following grades:

- Overall results—7th grade,
- Students with disabilities—7th grade,
- Students receiving free and reduced lunch—7th grade,
- Students scoring a Level 1 on FSA ELA—7th grade,
- Students scoring a Level 2 on FSA ELA—7th grade,
- Students scoring Level 3 on FSA ELA—8th grade, and
- Students scoring Level 4 on FSA ELA—7th grade.

The means scores were higher, with significance, for students whose teachers attended one professional development opportunity than the mean scores of students whose teachers did not attend one professional development opportunity in the following grades:

- Students receiving free and reduced lunch—6th grade and 8th grade,
- Students scoring a Level 1 on FSA ELA—6th grade,
- Students scoring a Level 2 on FSA ELA—6th grade and 7th grade,
- Students scoring a Level 3 on FSA ELA—7th grade,

- Overall results—6th grade, and
- Students with disabilities—6th grade.

Additional analysis showed that the mean scores of 8th-grade students whose teachers attended one professional development opportunity were not higher than the scores of 8th-grade students whose teachers did not attend one professional development opportunity a year prior to participating in the study. The other groups of students' mean scores for the 2014-2015 school year were higher with significance before the teacher attended one professional development opportunity.

Research indicates that student characteristics can have an impact on the implementation of new skills, knowledge, and strategies learned during professional development activities (Desimone, 2009), along with demographic factors (Bianchini & Cavazon, 2006). The implementation of new skills, knowledge, and strategies may have precipitated the increase in student achievement for the heterogeneous student demographic of students receiving free and reduced lunch. The amount of time available to implement the professional development strategies also may have been a factor in the implementation; teachers may not have had enough time or support to implement the strategies (Asseri, 2015).

In addition to time, research states that a barrier to teacher implementation of professional development strategies may consist of inadequate or missing support from administrators and district staff, along with a lack of support from fellow teachers. The teachers attending one professional development opportunity may not have had the support of the school administration because they spent less time in professional development (Lewis et al., 2015). Student characteristics such as reading level also may have been a barrier to growth, even if professional development strategies were implemented (Desimone, 2009).

Ultimately, the barrier to teacher implementation may be the lack of content or pedagogical knowledge that one professional development opportunity would not be able to address. Teacher may not have dug deep enough into concepts to impact student achievement (Luft et al., 2011). Finally, the teachers attending one professional development may not have had enough prior knowledge to implement the professional development opportunities (Henning, 2012).

Conclusion

The findings show that, for two groups of students' mean scores were significantly different and a change from the 2014-2015 school year data.

1. The mean scores of 8th-grade students receiving free and reduced lunch whose teachers attended one professional development opportunity were higher than mean scores of 8th-grade students whose teachers did not attend one professional development opportunity. Additional analysis indicates that, for the 2014-2015 school year, mean score of 8th-grade students (receiving free and reduced lunch) whose teachers did not attend one professional development opportunity did not have a significantly different mean score as compared to 8th-grade students (receiving free and reduced lunch) whose teachers attended one professional development opportunity.
2. The 7th-grade students who scored a Level 3 on FSA ELA whose teachers attended two professional development opportunities had higher mean scores than students

who scored a Level 3 on FSA ELA whose teachers did not attend two professional development opportunities. Additional analysis indicates that, for the 2014-2015 school year, the mean scores of students who scored a Level 3 on FSA ELA whose teachers attended two professional development opportunities were not statistically significantly higher than the mean scores of students who scored a Level 3 on FSA ELA whose teachers did not attend two professional development opportunities.

3. The 7th-grade teachers who attended two and three professional development opportunities had statistically significant higher student mean scores (overall) before and after attending two professional development opportunities. It is unclear how the professional development opportunities impacted students' achievement based on prior year data.
4. The 6th-grade teachers who attended one professional development opportunity had statistically significant higher student mean scores (overall) before and after attending one professional development opportunity. It is unclear whether the professional development impacted students' achievement.
5. The 8th-grade teachers who attended one, two, or three professional development opportunities had lower student mean scores (overall) than teachers who did not attend any professional development opportunities, and, in many 8th-grade subgroups, teachers who attended professional development opportunities had student mean scores that were lower than their peers (8th-grade teachers) who did not attend any professional development opportunities. Research states there could have been multiple barriers that caused the lower mean scores.

6. The 6th-grade teachers who attended three professional development opportunities had lower student mean scores overall than teachers who did not attend professional development opportunities. In 6th-grade subgroups, many teachers who attended professional development opportunities had lower student mean scores than teachers who did not attend three professional development opportunities. Research states there could have been multiple barriers to cause the lower mean scores.

Implications and Recommendations for Practice

1. It is recommended that time is needed for professional development strategies to be implemented before scores are examined to determine how the professional development impacted student achievement.
2. It is recommended that other measurement tools be used to measure student achievement and teacher implementation of professional development strategies to accompany standardized assessment scores.
3. It is recommended that support from learning communities, school administration, and district leadership be present when teachers are implementing professional development opportunities.
4. It is recommended that teachers be given the time needed to implement inquiry practices in the classroom.

<u>Recommendations for Further Research</u>

1. It is recommended that other instruments be used to measure the impact of professional development on student achievement in science. This is recommended to research different aspects of teacher professional development.
2. It is recommended that two years of individual teacher data be examined to determine growth in student achievement for teachers who participate in ongoing science professional development opportunities. This is recommended to research if teacher grew individually.
3. It is recommended that science assessment scores and reading assessment scores be examined for predication purposes. This is recommended to research the high correlation between reading scores and science scores on standardized assessments.
4. It is recommended that standardized scores for participants and non-participants be gathered for a longitudinal study. This is recommended to research multiple years to examine growth after professional development opportunities.
5. It is recommended that further statistical analysis be done to determine the relationship between the subgroup demographics and the student score. A regression analysis could be implemented to determine the weight of the subgroup on the overall score and how it differs for the teachers who attended the professional development opportunities and those who did not.
6. It is recommended that the implementation barriers for the 6th and 8th-grade teachers who attended the professional development opportunities be studied.

This is recommended to research the barriers to implementing professional development.

APPENDIX A
IRB APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901, 407-882-2012 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

NOT HUMAN RESEARCH DETERMINATION

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

To : **Leah Torres**

Date : **August 26, 2016**

Dear Researcher:

On 08/26/2016 the IRB determined that the following proposed activity is not human research as defined by DHHS regulations at 45 CFR 46 or FDA regulations at 21 CFR 50/56:

Type of Review:	Not Human Research Determination
Project Title:	The Impact of Ongoing Science Professional Development on the Achievement of Students on Standardized Assessments
Investigator:	Leah Torres
IRB ID:	SBE-16-12439
Funding Agency:	
Grant Title:	
Research ID:	N/A

University of Central Florida IRB review and approval is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are to be made and there are questions about whether these activities are research involving human subjects, please contact the IRB office to discuss the proposed changes.

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

Signature applied by Patria Davis on 08/26/2016 10:21:21 AM EDT

IRB Coordinator

APPENDIX B
PERMISSION FROM SCHOOL DISTRICT OF OSCEOLA COUNTY

THE SCHOOL DISTRICT OF OSCEOLA COUNTY, FLORIDA
817 Bill Beck Boulevard • Kissimmee• Florida 34744-4492
Phone: 407-870-4600 • Fax: 407-870-4010 • www.osceolaschools.net

January 24, 2017

Ms. Leah Torres
3241 Amberley Park Circle
Kissimmee, FL 34743

Dear Ms. Torres:

This letter is to inform you that we have received your request to conduct research in our School District. Based on the description of the research you intend to conduct, I am pleased to inform you that you may proceed with your work as you have outlined. Please be advised that this approval is based on the understanding that a school's participation is completely voluntary and left to the discretion of each building administrator. Please also be advised that the district office will not be able to assist you with any aspect of your research (e.g. sending emails, obtaining data, locating students, providing addresses, etc.).

Finally, be reminded that all information obtained for the purpose of your research must be dealt with in the strictest of confidentiality. At no time is it acceptable to release any student or staff identifiable information.

I wish you the best of luck in your future endeavors. If I can be further assistance, please do not hesitate to contact me.

Sincerely,

Janine Jarvis, Director
Research, Evaluation & Accountability

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