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Eighth-Grade Students with Low Academic Performance in Middle School Science

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,

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2018

Abstract

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MA, Central Michigan University, 2012

BS, Clayton State University, 2010

Doctoral Study Submitted in Partial Fulfillment

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Abstract

The problem of low achievement and failure of 8th-grade students to attain state proficiency level in science in a local school district was addressed in this case study. Data from 2012–2016 revealed that 93% of 8th-grade students in 2 suburban middle schools in the targeted state failed to meet science proficiency standards on the science Criterion-Referenced Competency Tests and the state's Milestone Assessments. The purpose of conducting this qualitative case study was to develop an understanding of teachers' perceptions regarding high failure rate of 8th-grade students to meet state mandated standards in science. Piaget's constructs of developmental and operational learning were used as the conceptual framework. Guiding questions were used to explore teacher perceptions of the challenges middle school students experience in learning science, as well as developmental and operational learning characteristics affecting science achievement. Data were collected from interviews with 12 middle school science teachers at the two schools. Data were analyzed using open coding and thematic analysis and were checked for accuracy through member checking. Common themes were behavioral issues, lack of concept application, lack of intellectual development, the need for relatable instructional strategies, and the need for teachers' professional development. A professional development program for teachers was constructed as a project to address each of these themes. The study may affect positive social change by providing teachers and stakeholders with a deeper understanding of student needs in science learning and improved instructional strategies for teachers to enhance students' science achievement.

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Dedication

I would like to dedicate this study to my loving family for their support and continuous encouragement. Also, I would like to thank Dr. Shoemaker, Dr. Cale, Dr. Stoudt, and Dr. Hunt for helping me to accomplish my goal. Most importantly, I give God all the praise for helping me persevere through this journey.

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Section 1: The Problem

The level of mathematics and science achievement of students in America has been a major area of concern for the last 50 years (Pinder, 2013). America's gap in science achievement, sometimes referred to as the "Silent Epidemic," stems from some school systems that are ineffective because of their disregard for teaching fundamental principles like teaching and applying the scientific method, and the residual consequences of inadequate scientific knowledge (Netterfield, 2011). Because of this concern, American schools have tried to recognize the significance of science in education (Archer-Bradshaw, 2015; Xie & Killewald, 2012). One key component in scientific literacy is the scientific method. However, over the past 10 to 20 years, students have failed to learn the steps of the scientific method, which include critical thinking. Critical thinking skills impact overall academic achievement. Poor critical thinking skills negatively affect the contributions made to science by our society (Ross, Hooten, & Cohen, 2013). Ross et al. (2013) posited that science and technology advancements have become essential to our world, requiring schools to change the curriculum to foster the relevant learning environment that helps students think critically and prepares them for future science careers.

The Local Problem

Peach Middle School and Pear Middle School (pseudonyms) are two of many middle schools in Georgia that have recorded low scores in science from the 2012-2013 school year through the 2016-2017 school year. In response to these low science scores, the targeted county provides a formal curriculum guide for teachers to follow. The curriculum guide provides teachers with an overview of what students are expected to learn in math, language arts, science, and social studies. The curriculum guide was created for students in Grades 6 through 8. However, during a meeting held at one of the schools within the targeted county, some staff and community leaders expressed that the science curriculum guide lacks clear teaching strategies, overlooks professional skill capacity, and underestimates the significance of facilitation techniques needed to encourage student engagement (Target County School District meeting notes, August 4, 2016). According to the 2017 school accountability reports, only 2.2% of Peach Middle School and 13.2% of Pear Middle School eighth graders were proficient or above in science (Georgia Department of Education [GDOE], 2017). Furthermore, of the 27 middle schools located in the targeted county, only seven of those schools' eighth-grade students were proficient or above in science (GDOE, 2017). According to data from the GDOE (2017), 15 out of 27 middle schools within the targeted county have eighth-grade students not meeting proficiency in science. Even though this study focused on two middle schools within the targeted county, other schools may benefit from this research, because meeting science proficiency is an issue for many middle schools.

Rationale

Evidence of the Problem at the Local Level

Due to low performance of eighth-grade students in science at both Peach Middle School and Pear Middle School during academic years 2014-2015 through 2016-2017, in-depth research was necessary to examine why eighth-grade students are not meeting the state science standards. Science performance was measured by the Criterion-Referenced Competency Tests (CRCT) until the beginning of the 2014-2015 school year, at which time the state adopted the Georgia Milestones Standardized Test (GMST). In the

2016-2017 school year approximately 81% of the eighth graders at Peach Middle School and 63.5% of eighth graders at Pear Middle School received a *beginning learner* score factor on the GMST (GDOE, 2017). However, only 19% of the eighth-grade students at Peach Middle School Middle School met or exceeded these expectations for this test, and at Pear Middle School 36.3% met or exceeded these expectations on the GMST (GDOE, 2017). Students at both Peach and Pear Middle Schools who performed poorly in science were unable to participate in certain school programs, such as science, technology, engineering, and math (STEM) programs. This policy has continued with the implementation of the GMST (Target County Board, 2017).

Teachers and students at Peach and Pear Middle Schools have had access to resources, which are available to assist teachers in helping students to learn science. Traditional teaching strategies and instructional activities from 2014-2015 through 2016-2017 were used as the media for teaching content in science. The Georgia Standards website (2017) was available as an online resource for students, including a practice tool. The online website's practice tool was also used by teachers within the classroom setting to improve student skill sets, context understanding of cells and genetics, as well as interdependence of life and evolution (Target County School Board, 2017). Students could use the practice tool to gain an in-depth understanding of subject matter and to learn practical problem-solving techniques. Teachers could observe student engagement with similar science content standards, address questions about the material, and gauge learning capacity, and achievement levels (Target County Board, 2017).

However, even with multiple resources available, test data showed that students were not making improvements in science. Georgia teachers are required to design instruction based on the Georgia Common Core Standards of Excellence. These standards are intended to assist teachers with knowing the content standards they are responsible for teaching and for preparing students for the GMST (Georgia State Standards, 2017). According to 2016 data from the GDOE, the GMST accomplishes the following: (a) ensure that students are learning; and (b) provide data to teachers, schools, and school districts. Consequently, educators can make better instructional decisions and provide data for use in Georgia's accountability measures and reports. The results of the GMST are used to measure the academic achievement of students, classes, schools, and school systems.

Teachers and administrators conduct routine meetings to discuss the results of both the practice and official GMST scores. These meetings encourage meaningful dialogue to problem-solve unsuccessful outcomes and to propose alternative strategies to address poor performance. Teachers and administrators at Peach Middle School and Pear Middle School meet yearly to review the newest GMST data and compare that with past test scores. During this meeting, GMST data are discussed and used to establish short- and long-term goals for the upcoming school year.

Teachers, administrators, and the community stakeholders understand the impending consequences of GMST and Adequate Yearly Progress (AYP) data that fail to meet Georgia requirements for assessments. The state can impose escalating sanctions on schools, permit students to transfer to other public schools, cut off school funding, force schools to pay for students from low-income families to enroll in after-school tutoring programs, and ultimately, close persistently failing schools (United States Department of Education [USDOE], 2017). In order to improve student learning, local districts must analyze their instructional practices and tools, weigh their teacher effectiveness, consider how well their students are being prepared for the 21st century job market, and examine broader implications of deficits in science education (Eagleton, 2017).

Instructional practices and tools. One aspect of addressing the problem of poor science achievement on the local level is to analyze instructional practices and tools. Schools have the challenge of preparing students to learn science and engineering by using effective instructional strategies that will help them connect science to their lives (Freeman et al., 2014). The study of instructional strategies, usage of innovative tools, lesson plan implementation, and classroom management is critical to the establishment of an effective learning environment for students (Conner & Sliwka, 2014). An effective classroom environment helps students gain the necessary skills for learning success (Tunca, 2015). A positive classroom setting can motivate students to thrive and maximize instruction (Chumbley, Haynes, & Stofer, 2015). The maximum learning of content is crucial to lay a foundation upon which to build. Piaget's theory states that learners can best construct innovative understanding through prior knowledge and experiences (Barrouillet, 2015).

One instructional strategy that teachers use is problem-based learning (PBL), which is a student-centered teaching approach. PBL encourages students to learn and understand subject matter through the experience of problem-solving activities (English & Kitsantas, 2013). PBL strategy and Piaget's theory both center on the significance of integrating the learner's motivation to understand content matter through their experience, reflection and critical reasoning process.

Teacher effectiveness. Another aspect of addressing the problem of poor science achievement on the local level is analyzing teacher effectiveness, which is acknowledged to be one of the most important factors influencing what students learn (Welch, Pitts, Tenini, Kuenlen, & Wood, 2010). Highly qualified teachers find effective ways to advance academic studies by stimulating student interests to explore, learn and retain science concepts. Furthermore, teacher effectiveness may influence students' success on standardized tests. However, some teachers have resorted to teaching only the concepts on which students will be tested, due to the need to improve standardized test scores (Hitt & Tucker, 2016).

Research supports the need for teachers to teach the content versus teaching to the test. The most common criticism of standardized testing is that teachers find themselves teaching to the test instead of teaching the various content and skill areas of the curriculum. In recent years, standardized tests have become the predominant tool used to determine a student's progress. Such tests are also used to promote or retain a student at the current grade level, and to identify whether a learning disability exists (Bhattacharyya, Junot, & Clark, 2013). While these are important functions of a test, tests cannot be the sole focus for instruction. Effective teachers must teach the content, which should be preparing the student for the assessment, but should also be preparing the student for the future (Storksdieck, 2016).

21st century students should be prepared for careers that require them to be creative, innovative, critical thinkers, problem solvers and collaborators (Kola, 2013). Attention needs to be focused on American education's knowledge deficiencies in science, history, math, literature, and other subject areas that are important for success in the 21st century (Donovan, Green, & Mason, 2014). Some remedies are attainable, particularly when obstacles are more overt, such as outdated teaching strategies. However, ineffectual approaches to assessment preparation may have irrevocable ramifications. Reading fluency, cognitive ability, and conceptual thinking are characteristics that are not easily learned. Far too many middle school students are promoted to the next level despite their low-test scores and context deficiencies (Lynch, 2013). Inadequate performance is carried on to the next grade levels.

Broader implications. One final aspect of addressing the problem of poor science achievement on the local level is for schools to look at broader implications of deficits in science education. Students' underachievement in science extends beyond the local setting, a concern cited on a national academic scale. The United States has made it a priority to improve student achievement in math and science (Lochmiller, Huggins, & Acker-Hocevar, 2012). For the past 50 years, improving the quality of mathematics and science instruction has become a paramount objective (Pinder, 2013). Cavas, Cavas, Karaoglan, and Kisla (2009) emphasized that improvement in the science content area must begin with science teachers being knowledgeable in all areas of science. Additionally, Cavas et al. (2009) stressed the importance of teacher accountability to develop positive attitudes toward science and mathematics through motivational classroom experiences. With strong teacher content knowledge and motivational classrooms, teachers can help increase student engagement (Akers, 2017).

A common approach to student engagement is contingent on participation in the classroom. Successful results are noted when activities are based on everyday life experiences and relevant content information. Avoiding physical constraints, such as sitting in one place, is also important when encouraging engagement (Rukavina, Zuvic-

Butorac, Ledic, Milotic, & Jurdana-Sepics, 2012). Recent studies show some examples of indicators that influence cognitive engagement such as the use of learning strategies, execution of a particular work style, and self-regulated learning (Khosa & Volet, 2014; Lu & Churchill, 2014).

Educators who can recognize a student's cognitive emotion, which equates to understanding the relationship between interest, instrumentality, and self-regulation, have an opportunity to plan lessons and activities that stimulate academic engagement (Brickman, Alfaro, Weimer, & Watt, 2013). The ability exemplifies a greater awareness of critical motivational factors that inspire learning success. Ely, Ainley, and Pearce (2013) argued:

> From an educational practitioner's perspective, knowledge of patterns of situational interest may be used to direct attention to specific curriculum activities. The awareness may be helpful in personalizing a task so that students engage readily. Knowledge of students' more enduring individual interests may also be used to trigger a state of positive affect by engaging students' attention and willingness to explore thereby increasing their knowledge of interest content. (p. 13)

To support this type of student engagement, the targeted county provides a formal curriculum guide. The curriculum guide is a tool that gives an overview of content areas, concepts, skills, and processes. Teaching is such a "particularistic endeavor" that guiding teaching practice by one-size-fits-all test data will only take us so far (Popham, 2008, p. 27). Perhaps a better perspective on the role of data in education is that data helps teachers to assess the needs of their students and themselves as practitioners (Hargreaves, 2007).

Teachers have discussed their perceptions about inadequacies with the schools' instructional learning tools, student engagement, and their struggle with the implementation process (Targeted County School, 2017). Perhaps this research project helps determine if learner frustrations and teacher ineffectiveness inhibit the learning process. Behavioral cues such as anger, disengagement, and confusion may obstruct students' participation during learning activities (Gonida & Cortina, 2014). Teachers who have the ability and tools that are needed to manage such behaviors could help students obtain a valuable and focused learning experience (Helm, 2017). As noted by Dewey (1932), this fundamental endeavor is observed when the successful classroom teachers have a passion for knowledge, as well as an intellectual curiosity about the materials and methods they teach. Such educators possess an intrinsic curiosity and love for learning. These abilities differ from one's ability to acquire, recite, and reproduce textbook knowledge. Both teachers and students may experience frustration when it comes to meeting state requirements. Educators must understand these difficulties to implement a plan that will promote success for students (Pinder, 2013).

Evidence of the Problem from the Professional Literature

Low performance of eighth-grade students in science is not limited to the schools in this study. The need for student improvement in science is a topic that has been researched by many professionals. Mansfield and Woods-McConney (2012) offered opinions about how to circumvent achievement gaps in science. They believed this could be accomplished through research of teaching practices and tools used to prepare for science standardized tests. Student achievement is actually dependent on many factors.

Diversity. Jackson and Ash (2012), Olswang and Prelock (2015), and Pasley, Trygstad, and Banilower (2016) noted the growing need to minimize science gaps across diverse student populations. Jackson and Ash (2012) conducted a 3-year study with two high-poverty, ethnically diverse public elementary schools in Texas. Their research involved the following specific interventions: purposeful planning, inquiry science instruction, and contextually rich academic science vocabulary development (Jackson & Ash, 2012). Jackson and Ash used specific interventions for an ethnically diverse school. Ethnically diverse classrooms present teaching challenges. When educators are aware of differences in cultures and in learning styles, they can effectively implement teaching strategies that increase student learning (Wallace & Brooks, 2015). Therefore, teachers must be prepared to address the dimensions of diversity that influence opportunities to teach and learn science. Emmer and Evertson (2017) suggested that interactive learning is an imperative feature of science learning. Educators should use a variety of teaching methods, assessment tools, and online resources.

Self-efficacy. Teacher efficacy has become an important field of research, especially with those content areas teachers find challenging, such as science (Wyatt, 2016). Most notably, opportunities for collaboration and successful participation in science teaching practice are proven to enhance teachers' efficacy for science teaching. Although teacher efficacy is important, it is inadequate alone for students' academic achievement. Students' self-efficacy impacts academic achievement as well (Shahzad & Naureen, 2017). Both teacher and student efficacy are equally important to achieve optimal success in the classroom (Donovan et al., 2014; Griggs, Rimm-Kaufman, Merritt, & Patton, 2014).

Collaboration. In addition to teacher and student self-efficacy, student achievement in science has been affected by teacher team work. Acar and Yıldız (2016) and Can (2010) found an emerging theme in all science teacher focus groups, emphasizing the importance of opportunities for collaboration with colleagues. These studies examined teacher education among these professionals, and efficacy beliefs about teaching science. For example, teaching efficacy decreases when an educator feels he or she has an inadequate understanding of introductory science concepts. Overall, the participants of this current study reported both positive and negative experiences influenced their own approach to learning and teaching science curriculum. Further, opportunities for collaboration emerged from teaching context, which led to subject matter expertise. Teachers who function at high-level understanding may play a role in analysis of the effective teaching and assessment of personal competence. The role of effective teaching was also noted when teaching tasks involved team teaching with another more knowledgeable colleague (Acar & Yıldız, 2016; Can, 2010).

Quality instructors. The positive influence of more knowledgeable colleagues emphasizes the need for quality instructors. Educators agree that to increase student performance, the quality of the teachers placed into every classroom is of critical importance (Goldhaber, Gratz, & Theobald, 2016). However, they do not fully understand how to go about placing a highly-qualified teacher into every core classroom as mandated in No Child Left Behind (NCLB, 2002). Professional development and support from administration help maintain highly-qualified teachers. Cavas et al. (2009) found, in the last 20 years, initiatives related to use of information and communication technologies (ICT) in education motivate teachers to gain subject matter knowledge and skills in using ICT in their instruction.

Effective teaching strategies are needed to improve students' math and science skills. Instructional practices are as multifaceted as student learning styles. These strategies and practices can be fostered by administrators who are actively involved with the teachers. According to Lochmiller et al. (2012), leaders of instruction have the ability to influence teachers by working collaboratively with them to improve instruction for students. When schools demonstrate dramatic gains in academic achievement, this endeavor is considered a residual influence of effective school models. When academic achievements are realized in the public-school setting, one may consider whether a student's ability to pass a standardized test is contingent on the quality of instruction received. The quality of instruction is important because it prepares the student for standardized tests (Sornson, 2015).

Instructional time and test preparation. In addition to professional development and administrators' support, student achievement in science has been affected by federal mandates regarding instructional time allotted to various subjects. NCLB legislation was developed for many reasons, including the need to diminish student achievement gaps. Dresser (2012) indicated that weak reading skills were having a negative impact in all subjects. Although students had proficient decoding skills, they struggled with reading comprehension and content knowledge. To this end, NCLB mandated 2 hours for reading and 1 hour for math coursework each day for schools to maintain eligibility for certain funds. Bhattacharyya et al. (2013) noted several concerns expressed by teachers. One teacher felt with the time mandated for reading and math, students were not getting enough time for science and social studies. Bhattacharyya et al.

(2013) stated because of these NCLB directives, other content areas such as science become irrelevant. Another teacher indicated frustration that instructional time was to be focused on preparing for high-stakes tests, not leaving time for covering the subject curriculum. Devoting the needed time to grasp core subjects will help students learn the content and give them an opportunity to master what they have learned (Farbman, 2015), which may positively affect standardized test outcomes.

Science literacy is achieved when teachers are equipped with the knowledge and skills necessary to facilitate scientific concepts within a classroom of diverse learners (Chinn, 2012; Kok-Sing, 2016). The review of professional literature provides many perspectives as to why students are not performing well in science. My intent for this study project was to explore factors, such as those presented in professional literature, contributing to science underachievement in eighth-grade students in two middle schools.

Definition of the Problem

The problem is that only 32% of all eighth-grade students in the United States are achieving National Science Education Standards (NSES) benchmark expectations (National Assessment of Educational Progress [NAEP], 2016). Bursal (2013) investigated science academic achievement of 222 elementary and middle school students, finding science scores decreased as students’ grade level increased in Grades 4 through 8. Bursal indicated on the national level students are not meeting proficiency in science. Several possible reasons explain why students are not meeting standards in science curricula. One of these reasons is students have difficulty meeting grade level expectations throughout academic content areas (Hunley, Davies, & Miller, 2013). Sagirli (2016) and Yüksel and Geban (2016) found insufficient content area knowledge and under-developed skill sets negatively impact both individual students and schools, resulting in under-performance in all content areas, including science.

As schools experience a decline in science test scores, they need to develop a plan to support and encourage improved performance in science (NAEP, 2016). To address this decline, many US schools are in the process of implementing programs to improve science. However, the core of discussion is ensuring teachers know what to teach and how to teach it (USDOE, 2015). According to the USDOE (2015), if proactive measures are not taken, this trend will impact the role of the United States as a global leader in science.

Definitions

The following terms and definitions were used in this study:

Collaborative group work: Students are organized into designated peer groups to maximize learning. The identification of the placement criteria of the learners in the given groups depends on their individual ability (Kershner, Warwick, Mercer, & Staarman, 2014). The students who have been identified to be weak in certain areas are grouped with stronger students in that area to foster the learning process.

Criterion Referenced Competency Test (CRCT): According to the GDOE website (2014), CRCT is designed to measure how well students acquire the skills and knowledge described in the state mandated content standards in reading, English/language arts, mathematics, science and social studies. The assessments yield information on academic achievement at the student, class, school, system, and state levels. The information is used to analyze individual student strengths and weaknesses as related to the instruction of the state standards, and to gauge the quality of education throughout Georgia.

Definitional information on multiple contexts: According to Bintz (2011), the multiple contexts approach allows the students to have a variety of ideas on a topic and they discover how their ideas can help them understand the new concept. The process of students discovering how to make connections from previous material learned with a new concept or idea may increase student understanding.

Inspired teaching: According to Wood, Thall, and Parnell (2015), the primary consideration of the inspired teaching approach encourages all learners to be actively involved in the lesson. Inspired teaching provides learners the opportunity to anticipate the content before it is taught. For example, some teachers use word clouds that contain several random words suggestive of the topic that is pending discussion. Students can discuss what they know about the topic, as well as what they want to learn about the topic.

Student Response System (SRS): An SRS is an individual remote-control keypad, designed with multiple choice questions that are displayed on a screen. The SRS is used on many levels, kindergarten through 12th grade (Kaiser & Wisniewski, 2012). Kaiser and Wisniewski (2012) conducted a preliminary study, using SRS to explore the academic achievement and engagement of a particular middle school classroom.

Significance

From the 2012-2013 school year through the 2016-2017 school year, the two schools in this study introduced changes in the science department and curriculum. However, according to 2016-2017 test results, science standardized test scores showed no improvement. The purpose of this study was to investigate why eighth-grade students are not meeting the Georgia science standards. The study is significant because standardized science test scores are consistently low, both locally and nationwide (NAEP, 2016). Locally, 15 out of 27 middle schools in the same county as the two schools in this study have not met proficiency in science.

The NAEP (2016) reported that students have not made the expected gains in science. Conducting a comprehensive study that leads to pragmatic implementation of instructional best practice was the focus of this study. According to Hussain, Jamil, Noor, Sibtain, and Shah (2011) approximately 75% of US students who have completed eight years of school failed to achieve passing grades. Analyzing combined science grades, Husain et al. found less than 20% of students maintaining grades A to C in science classes.

A quality education is contingent upon an effective teaching and learning process. Specific fundamentals of learning enhance successful classroom instruction (Barattucci, 2017). Hussain et al. (2011) assessed the efficacy of the learning process by analyzing several elements. Teacher experience, teacher competencies, pre-service and in-service training, teacher-student interaction, efficient use of instructional time and materials, and assessment of student achievement were used to assess the efficacy of the learning process. The information might be a useful resource for teachers when teaching science curricula.

As a parent of an eighth-grade student who recently failed the science portion of the CRCT yet achieved an *A* average in science, I was compelled to research relevant data that may illuminate useful instructional practices that could help to improve students' performance in science. The county provides a formal curriculum guide, which presents an overview of content areas, concepts, skills, and processes used to support student development. Helping teachers to be more effective in the classroom may influence learning outcomes and help students be successful (Welch et al., 2010). Therefore development of a project based on the findings of this study may address the problem (Appendix A).

Guiding/Research Questions

The purpose for engaging in this study was to develop an understanding of teachers' perceptions of why eighth-grade students have consistently failed to meet state-mandated standards in science curricula. The study explored how teachers apply Piagetian developmental milestones to analyze student learning. The following questions guided this study:

Guiding Question 1

What are teachers' perceptions of challenges of teaching science to eighth-grade students and of how their students relate what they have learned to the world around them?

Guiding Question 2

What developmental and operational learning characteristics are viewed by science teachers as affecting the achievement of proficiency in science learning?

Constructivist theorists purport that learning occurs based on how people perceive their world. Science education is directly connected with the way the world works. Challenges that middle school students encounter in learning science might be related to the way in which they perceive science and whether they can concretize science learning to the way they construct their world (Fosnot, 2013; Gordon, 2009). The ability of middle school students to concretize science learning to the way they construct their world hinges upon their developmental and cognitive operational skills. The first research question guiding this study related to teachers' perceptions of the challenges middle school students experience based on the way they construct their world in relation to science learning. The way students construct their world may reflect the developmental and operational skills of middle school students within the context of Piaget's cognitive development theory (Ghazi & Ullah, 2015). The connection of developmental and operational skills to constructivism and achievement was the focus behind the second research question.

The research questions are important to this study because research findings can positively influence professional effectiveness, including classroom setting, tools and resources, and even student preparedness. Participating science teachers were asked to assess benefits and constraints posed by diverse learning, student performance, and tried-and-true instructional strategies. Moreover, responses to these questions revealed reasons why achieving academic success is elusive or what can contribute to improvement.

Review of Literature

Past research has indicated that science education contributes to the development of critical thinking skills in students (Archer-Bradshaw, 2015; Pinder, 2013; Xie & Killewald, 2012). Research has also indicated that proficiency in science increases students' proficiency in critical thinking skills that are applied to all other areas of learning and improves overall academic success. However, research into recent performance of students in middle and high schools in the United States has indicated declining performance in mathematics and science (Archer-Bradshaw, 2015; Pinder 2013; Ross et al., 2013; Xie & Killewald, 2012).

Comparative analysis of the performance of students in science globally revealed that the performance of students in the United States in science has fallen behind the performance of students in other nations in the world (Carillo & Papagni, 2013; Koosimile & Suping, 2015). Benchmarks were identified in the Next Generation Science Standards (NGSS) that are concomitant with international standards for performance in science (NGSS, 2013; Penuel, Harris, & DeBarger, 2015). These benchmarks were earmarked for implementation at the national level (NGSS, 2013; Penuel et al., 2015). However, appraisal of students' performance in the very recent past indicated that students in middle and high schools across the nation were performing below the proficiency benchmarks in science (Haigen & Guodong, 2016; Hammond, 2014).

Science education includes subject areas of science, technology, engineering, and mathematics (STEM; NGSS, 2013; Penuel et al., 2015). Poor performance in these critical subject areas has implications for students' overall academic performance, as well as implications for national socioeconomic development (Archer-Bradshaw, 2015; Haigen & Guodong, 2016; Ross et al., 2013). As such, there is a critical need to address this problem of poor performance in science and the inherent problem of lowered critical thinking skill attainment for middle and high school students. The problem is that eighth graders are consistently failing to meet state-mandated science score standards. The purpose for engaging in this study was to obtain teachers' perceptions of why eighth-grade students have consistently failed to meet state mandated standards in science curricula.

In this literature review, I will provide a description of my search strategy. I will also present the theoretical framework that undergirded the study and an expanded background on students' performance in science. Next, I will provide a description of the problem of poor performance in science among students, and teachers' perceptions of the challenges associated with poor performance. Furthermore, I will discuss science education and globalization. In the next section, I will present a discussion of the measures identified in the research to address these challenges and their relationship with the current study. In the final section I will address a discussion of gaps in the literature and the implications for this study. The section ends with a summary and a preview of the next section.

Literature Search Strategy

For this literature review I used the following databases and search engines: Educational Information Center (ERIC), Education Research Complete, ProQuest Central, Google Scholar, JSTOR: Journal Storage, PubMed, and EBSCOhost. The literature search included peer reviewed articles published between 2012 and 2018 to ensure that the most recent and up-to-date research was included in this study. The use of sources prior to 2012 was limited only to those sources with information that was highly relevant to the study. Key words and string searches included: *CRCT, differentiation, science achievement, teacher perspective, science success in classrooms, science proficiency among students, benefits of science education, ethical considerations in science education, cognition and science education, challenges in teaching science, cognition and learning science, next generation science standards, factors that affect* *teaching science* and *low science test scores*. I included all the key terms and string searches that yielded studies relevant to the research study and problem and were included in this literature review.

Theoretical Framework

An examination of relevant theories allowed me to establish a conceptual framework to support the importance of this study. The first theory in the framework was that of constructivism. The other key theory guiding this study was Piaget's theory of cognitive development.

Constructivism. The constructivist theory presents the argument that learners' experiences tend to play an important role in molding them and shaping their behaviors and perceptions about pertinent learning processes (Gordon, 2009). Powell and Kalina (2009) stated that, although the theory of constructivism is based on explicit concepts, the benefits and teaching applications are multifaceted. The effectiveness of this theory is contingent on individual learning, life experiences, and engagement, which enhances the student's cognitive skill and critical thought process (Fosnot, 2013). Given the need for improving standardized science scores, schools may benefit from this theory (Gordon, 2009). Powell and Kalina's philosophy draws parallels with the focus of this study, exploring reasons for low test scores in science, the impact on academic achievement, and teaching strategies to engage students. Because instructional methodologies are varied, knowledgeable and perceptive teachers ensure a greater success rate (Fosnot, 2013). Skilled teachers need to know how to effectively assess students' learning styles and subject knowledge and how to engage them in activities that will take them to their next level (Corbin, 2017; Fosnot, 2013; Gordon, 2009). Constructivism is an approach that allows opportunities for students to associate and create personal experiences needed to build on new information, and to synthesize the new concepts already established in their brains (Fosnot, 2013; Gordon, 2009).

Constructivism can be applied to the way students learn science when they can assimilate the knowledge with their personal experiences and the world around them (Scogin, Kruger, Jekkals, & Steinfeldt, 2017). A teacher's ability to evaluate each student's level of comprehension is critical. Ideally, educators would be able to integrate effective learning tools, create differentiated lesson plans, and facilitate high-level instruction, while enhancing optimal understanding among students (Fosnot, 2013; Gordon, 2009). According to Powell and Kalina (2009), "In cognitive constructivism, ideas are constructed in individuals through a personal process, as opposed to social constructivism where ideas are constructed through interaction with the teacher and other students" (p. 241). Constructivism asserts that students building their own knowledge and connections among concepts enhances learning, which would be applicable to this study investigating how to address low standardized science scores.

Piaget's cognitive theory. Another theory applicable to this study was Piaget's cognitive theory, which is critical in the comprehension of learning. Piaget's four stages of development are sensorimotor, preoperational, concrete operational, and formal operational (Ghazi & Ullah, 2015). Piaget identified the concrete operational stage as occurring between the ages of seven and eleven (Barrouillet, 2015). The concrete operational development stage refers to the cognitive abilities in children to process, understand, and engage in mental operations and thoughts using concrete concepts. In a study to assess the applicability of Piaget's cognitive development learning theory at the concrete operational stage, Ghazi and Ullah (2015) conducted a study engaging 200 urban and rural students. Ghazi and Ullah concluded that sociocultural environments are critical elements that facilitate cognitive development through science education. Science education can be provided using hands-on, active learning as the concrete element that enhances concrete operational development. Students in three subject areas: biology, chemistry, and physics, were analyzed in this study. Findings confirmed that science education in these three disciplines were efficacious in developing cognitive skills in students between the ages of seven and 11 who are at the concrete operational stage (Ghazi & Ullah, 2015).

The formal operational stage begins right around the time students are transitioning into middle school, which was the focus for this current study (G. Brown, 2013; Ghazi & Ullah, 2015). During this stage of formal operation, children start to use higher levels of thinking (G. Brown, 2013; Ghazi & Ullah, 2015). For example, they use their experience to create logical, mathematical concepts, and rules of inference for advanced conceptualizations (Powell & Kalina, 2009). Piaget's cognitive theory could be applied to student's learning science in middle school. Given the dynamic brain processes that are engaged in active learning within the various science disciplines, science education could be designed to target the development and enhancement of higher order cognitive skills and executive functioning (Jegstad & Sinnes, 2015; Kim, Sharma, Land, & Furlong, 2013).

Unfortunately, many students are unable to think critically or on a higher level due to environmental or academic factors affecting their understanding of the science curriculum (Hoffman, Collins, & Schickedanz, 2015). Failure to establish the foundational skills that are critical for learning science during the earlier years of formal education presents challenges to learning science in middle and high school (Hoffman et al., 2015). Concentration on the use of informational text and a reduction of emphasis on the development of critical skills have been cited as being responsible for the absence of critical thinking skills required to engage in the analytical process that is used in the scientific method (Beilin & Pufall, 2013; Hoffman et al., 2015). Additionally, when a student is learning science through informational text, the text can present vocabulary and ideas unfamiliar to the students, which may affect how well they can master the material (Beilin & Pufall, 2013; Hoffman et al., 2015). If critical thinking skills are not adequately developed, then the use of informational text and the way that students experience learning related to vocabulary and ideas might be limited.

Critical thinking skills influence the way that students interact with learning materials and the way that learning occurs. Critical thinking allows the student to bridge the gap between new knowledge that might present cognitive dissonance and the way that this new material is cognitively incorporated to acquired knowledge and concepts. In giving an account of Piaget's theory, Powell and Kalina (2009) stated "equilibration occurs when children shift from one stage to another and is manifested with a cognitive conflict, a state of mental unbalance or disequilibrium in trying to make sense of the data or information they are receiving" (p. 243). Xia, Caulfield, and Ferns (2015) stated that knowledge building is an expectation when transitioning to the next grade level. Piaget's cognitive development theory hinges on the knowledge-building processes of assimilation and accommodation. Assimilation poses a more natural approach, as student learning is influenced by prior knowledge and experiences. As children age, the accommodation process is thought to be more challenging (Gordon, 2009). Learners must adapt to a changing educational environment.

The purpose of this study was to develop an understanding of teachers' perceptions of why eighth-grade students have consistently failed to meet state mandated standards in science curricula. I used a case study to investigate possible reasons why students in the eighth-grade at Peach Middle School and Pear Middle School have not been meeting the science standards. I also examined teachers' perceptions regarding challenges in the facilitation of the science curriculum and how those challenges affect science achievement. Piaget's cognitive theory was particularly applicable to the current study in answering the second research question regarding students' developmental level and key characteristics associated with learning science. The theory of constructivism and Piaget's cognitive development theory may help in understanding why eighth-grade students are not being successful in science. Students' success in learning science might be related to the way they construct their world and the way that development influences their cognitive abilities (Gordon, 2009; Xia et al., 2015).

Students' Performance in Science

Statistics from the NAEP (2016) indicated that merely 34% of eighth-grade students in the State of Georgia performed at or above proficiency level in 2015. The average score in science for eighth-grade students in 2015 was 154, which was lower than 26 other states or jurisdictions and higher than nine states or jurisdictions (NAEP, 2016). Lowered performance and failure to achieve grade proficiency in science is a problem at the national level, state level, and local level (Humanities Indicators, 2016; NEAP, 2016). The public data were relevant to the problem being explored in this study.

[[The above was the last page I edited thoroughly, so please be sure to continue through this section and make the appropriate changes, as they are indicated above.]]

Benefits of Science Education

National and community levels. When measuring proficiency in science education, consideration must be given to the contextual elements of scientific knowledge and how this knowledge could be actively applied at the national, community and individual levels (Ghazi & Ullah, 2015; Jegstad & Sinnes, 2015; Kim et al., 2013; Kola, 2013; Lamanauskas, 2013; Nair, Mohamed, & Marimuthu, 2013; Özgüç & Cavkaytar, 2015). Science education promotes the development of cognitive skills foundational to all areas of academic achievement (Jegstad & Sinnes, 2015; Kola, 2013; Lamanauskas, 2013; Nair et al., 2013; Özgüç & Cavkaytar, 2015). At the national level, science education is critical for national development with the use and allocation of resources. These have implications for global leadership and for the United States maintaining a competitive edge in the global market (Jegstad & Sinnes, 2015; Kola, 2013; Lamanauskas, 2013; Nair et al., 2013; Özgüç & Cavkaytar, 2015).

At the community level, science education is relevant because of the impact of individual interaction with resources and the way individuals function within the community. Science education has implications for the quality of life, economic development, and for how science and technology are integrated into community and national life (Jegstad & Sinnes, 2015; Kola, 2013; Lamanauskas, 2013; Nair et al., 2013; Özgüç & Cavkaytar, 2015). Students' performance in science is of growing concern, especially considering the changing base of the economy (Naizer, Hawthorne, & Henley, 2014; Wang, Hsu, Campbell, Coster, & Longhurst, 2014). Proficiency in science education and science literature serves an important function in ensuring optimal functionality in society and the efficacious use of community resources (Ghazi & Ullah, 2015; Kim et al., 2013).

Individual level. At the individual level, science education is important for cognitive skills development and for the way that the individual processes and interacts with the environment. Science education promotes scientific thinking among students (Broks, 2014). Students trained in science education have learning experiences that assist in developing a range of cognitive skills that are applicable to their lived experiences. These include epistemological, theoretical, observational, and application of knowledge skills that help in the development of cognitive skills in students trained in the scientific process and scientific methodology (Broks, 2014; Brownell, Price, & Steinman, 2013; Griffith, 2013; Jegstad & Sinnes, 2015; G. Sarma, 2015).

Scientific method. The scientific method is a specific technique applied in scientific study, disciplines and research (Broks, 2014; Griffith, 2013; G. Sarma, 2015). The scientific method is an ongoing process that incorporates observation of a phenomenon in the real world. The scientific process begins with creating hypotheses or questions about a phenomenon and engaging in observation to test the hypotheses or questions to arrive at a conclusion based on the evidence retrieved. Students trained in the scientific methods develop a systematic approach to decision-making that applies the scientific process. Students transfer the skills acquired in scientific methodology to the way they process their experiences and the way they interact with others and their environment (Broks, 2014; Griffith, 2013; G. Sarma, 2015).

Epistemology. Students exposed to science education also acquire epistemological knowledge, which is a body of knowledge about the world and the way that the world functions (Broks, 2014; Brownell et al., 2013; Griffith, 2013; Jegstad & Sinnes, 2015; Kola, 2013; Lamanauskas, 2013; Nair et al., 2013; Özgüç & Cavkaytar, 2015; G. Sarma, 2015). Students who are proficient in scientific epistemology use this knowledge in a way that improves their understanding of the world. For example, students exposed to epistemological knowledge of environmental science are likely to apply this knowledge to how they treat the environment. Consequently, science education is significant for building science literacy in the general population (Kola, 2013; Lamanauskas, 2013; Nair et al., 2013; Özgüç & Cavkaytar, 2015).

The philosophy of science epistemology is grounded in an ongoing process of change (Kola, 2013; Lamanauskas, 2013; Nair et al., 2013; Özgüç & Cavkaytar, 2015). This change takes place in ongoing research. Seeking new answers and better ways to interact and process the world is critical to scientific and technological innovation. Consequently, proficiency in science education among students is an important element for future research and development that would lead to continued scientific and technological innovations (Kola, 2013; Lamanauskas, 2013; Nair et al., 2013; Özgüç & Cavkaytar, 2015).

Science Students: Critical Thinking and Cognitive Skills

Cognitive learning theory provides an explanation of how people learn based on individual brain processes that involve memory, problem-solving, critical thinking, and perceptual reasoning skills (Barrouillet, 2015). Science education engages students in critical thinking skills that require them to identify issues, observe patterns and behaviors, seek out evidence, critically analyze and evaluate data and evidence, make judgements, draw conclusions, and apply findings (Jegstad & Sinnes, 2015; Kim et al., 2013; Kola, 2013; Nair et al., 2013). When these skills are well developed, knowledge is transferred to other areas of the student's academic research and study, as well as to their lived experiences. These skills allow students to approach their life experiences from a more rational and informed perspective, which in turn enhances decision-making or higher order cognitive executive functioning (Jegstad & Sinnes, 2015; Kim et al., 2013; Kola, 2013; Nair et al., 2013).

In their study, Kim et al. (2013) posited that science education presents many opportunities for students to engage in problem solving tasks that require complex cognitive functions. Additionally, science education presents the opportunity for students to engage in active learning that enhances cognitive development and cognitive processes. Critical thinking skills that can be applied to life context are one of the benefits of science education (Jegstad & Sinnes, 2015; Kim et al., 2013). To demonstrate the efficacy of science education in developing critical thinking skills, Kim et al. engaged in a study that involved 155 undergraduate students at a public university. In their study Kim et al. designed two active-learning modules that allowed the participants the opportunity to apply the knowledge gained in specific science-based training in real-life context. According to constructivist theory, learning experiences are translated into the way that individuals perceive and construct their world (Fosnot, 2013).

Kim et al. (2013) used a quantitative methodology and interrater analysis to increase the scoring reliability of their findings. Findings from this study confirmed an increase in critical thinking skills, and application in life context between the two groups of students that were exposed to the active learning modules in this study. Following the exposure to the active learning that was designed to increase critical thinking skills, all participants demonstrated increased proficiency in problem identification, communication, developing decision-making strategies, and efficiency in their application of these skills to solving problems in life context. Additionally, all participants showed an increase in their mean scores based on measures of variables that indicated gains in critical thinking skills.

Metacognitive skills. Kim et al. (2013) concluded that science education could facilitate active learning experiences that could promote critical thinking skills and increase in application and judgment skills in life context. Uzuntiryaki-Kondakçi and Çapa-Aydin (2013) agreed, noting critical thinking skills encompass an array of cognitive skills and executive functioning. Reflective thinking is one aspect of critical thinking skills identified as meta-cognition. Meta-cognition is integral to the way an individual engages in reflection and self-regulation. Kim et al. and Uzuntiryaki-Kondakçi and Çapa-Aydin concluded that the benefits of science education are best earned as long-term gains. Contending that critical thinking skills relate to metacognition, Uzuntiryaki-Kondakçi and Çapa-Aydin posited that when students engage in reflective thinking in the critical thinking process, students reflect on themselves by monitoring their thinking to arrive at a specific goal or achieve a specific outcome. The process is evaluative in nature because students monitor their behavior, and this monitoring of behavior produces self-regulation. Consequently, this self-regulation is closely linked to the way students construct their world (Fosnot, 2013). The researchers further noted that epistemological readiness is an important component of the individual's philosophical approach to scientific knowledge (Kim et al., 2013).

Science literacy. Developing critical thinking skills leads to scientific literacy, which relates to how well the individual understands the nature of scientific knowledge, including its flexibility and the process for arriving at scientific conclusions (Cebesoy & Öztekin, 2016; Johnson, 2016; Kim et al., 2013; Uzuntiryaki-Kondakçi & Çapa-Aydin, 2013). Scientific literacy is an important element in science education. Scientific literacy refers to the personal knowledge, understanding, and approach to scientific concepts and the body of scientific knowledge and theory that the individual possesses. Scientific literacy is an important element among the general population and in personal day-to-day decision making. The individual's level of scientific literacy can affect decision-making concerning things such as pollution and recycling.

Science education is important as an element of scientific literacy in preparing individuals to live and function adequately in a society and world that is increasingly becoming scientific and technologically oriented (Ozdem-Yilmaz & Cavas, 2016). Science education is determined to be efficacious if delivered as active, hands-on learning. Science education could be delivered within the context of community resources with the aim of providing the hands-on, active learning experiences that would promote cognitive development (Ozdem-Yilmaz & Cavas, 2016).

Visuospatial skills. Visuospatial abilities are important cognitive abilities that are applied and developed in science education (Kell & Lubinski, 2013). Research findings have repeatedly shown that students with high visuospatial abilities demonstrate a higher interest in science, technology, engineering, and mathematics (STEM) training. Spatial ability is a cognitive process that individuals apply to learning in mathematics, science, reading abilities, and is critical in general educational performance (Kell & Lubinski, 2013). Science education is useful in developing high levels of spatial abilities. Students who are high functioning in visuospatial skills are better placed for entering higher education institutions. High functionality in visuospatial skills also offers graduating students better opportunities in key areas in science, technology, and military careers (Kell & Lubinski, 2013).

Executive functioning skills. Researchers exploring the role of cognition and social learning contend that executive function plays a significant role in how well students adapt to science learning (Diamond, 2013; Kell & Lubinski, 2013; Rhodes et al., 2012; Stevenson, 2012; Stevenson, Bergwerff, Heiser, & Resing, 2014). Executive functioning comprises a broad range of cognitive skillsets and their sub components that seem to have implications for specific aspects of learning (Rhodes et al, 2012; Stevenson, 2012). Exposure to educational experiences during the developmental stages enhances and optimizes the development of these cognitive skills.

Several critical executive functioning capabilities, including working memory, planning, and problem solving, have been realized to be important in the way the brain in children and adolescents processes information (Kell & Lubinski, 2013; Rhodes et al., 2012). Executive functioning has been shown to be related to broad domains of cognitive skills such as working memory and inductive reasoning (Stevenson, 2012; Stevenson et al., 2014). However, within each of these broad domains of executive function, other cognitive processes occur as subdomains operating at the micro level of the broader domains of executive functioning. These processes occur at the micro level and involve sub-components of aspects of broader cognitive functioning that influence how well students adapt to science learning (Stevenson et al., 2014). In an effort to explore the relationship between one aspect of executive function and conceptual learning in biology, Rhodes et al. (2014) engaged in a quantitative study and recruited 63 adolescents between the ages of 12 and 13 years over a period of 18 months. Rhodes et al. reported their findings substantiated findings from previous studies that established a link between executive working memory and learning science.

Working memory and inductive reasoning. Several studies have explored specific aspects of executive function within the subdomains of working memory and fluid reasoning (Diamond, 2013; Rhodes et al, 2012; Rhodes et al., 2014; St. Clair-Thompson, Overton, & Bugler, 2012; Stevenson, 2012; Stevenson et al., 2014). Working memory and inductive reasoning skills have been found to be related to how well students learn science (Stevenson et al., 2014). Given the importance of these cognitive skills to the successful learning of science and mathematics, it is imperative that students in middle school acquire those benchmarks that are reflective of the cognitive skills necessary for performing well in science prior to entering middle school (Nevo & Breznitz, 2013; Rhodes et al., 2012). In addition to developing those skills, it is also important that cognitive skills at the micro level within the broader range of executive function be developed with the aim of improving students' performance in science (Kell & Lubinski, 2013; Rhodes et al., 2012; Stevenson, 2012, Stevenson et al., 2014).

Four aspects of working memory that facilitate students' ability to process, store, and retrieve information have been identified as being critical to academic success (Kell & Lubinski, 2014; Rhodes et al., 2012). Fluid reasoning or the ability to adapt and apply past knowledge to solve new problems is also important for students to learn science successfully. Most learning in school requires apt application of these skillsets. These skillsets, working memory and inductive reasoning, are particularly relevant for science learning (Stevenson et al., 2014). On the other hand, science learning has also been known to further develop these skills in students. When these skillsets are well developed, they are transferred into other areas of academia (Kell & Lubinski, 2013; Rhodes et al., 2012; Stevenson et al., 2014).

Science learning is based on cognitive abilities that can be evaluated using assessments that measure ability at a specific point, as well as cognitive skills that are employed in the process of learning. The way that students apply their cognitive process during active learning can be measured using dynamic assessment. Students use fluid reasoning as part of the analytical process that is required in science learning. Analogical reasoning or the ability to apply past learning and knowledge to solve current or new problems can be measured using dynamic measures to assess how learning occurs at the micro level. Using dynamic testing instead of static assessment allowed researchers to gain a better understanding of how learning takes place (Stevenson, 2012; Stevenson et al., 2014).

In an effort to assess whether there were unique aspects of working memory and inductive reasoning that contributed to achievement and performance in mathematics and reasoning, Stevenson et al. (2014) engaged 188 children from five elementary schools in a quantitative study. Students were administered a dynamic test of analogical reasoning, verbal and visuospatial working memory, and scholastic achievement tests at two intervals. Findings from this study corroborated previous findings that students with higher working memory skills and those students who performed higher on dynamic measures of analogical reasoning generally obtained higher math and reading scores when tested on scholastic achievement tests.

Furthermore, the acquisition and development of these analogical skills during the learning process account for differences in performance that are not accounted for based on working memory and static elements of fluid reasoning (Stevenson et al., 2014). These cognitive domains have sub-skill sets that seem to be developed and acquired as part of the learning process. Targeting these skills in the learning process increases overall academic performance (Stevenson et al., 2014). These findings have implications for teaching methods and environmental context in which learning takes place (Stevenson et al., 2014).

Science Teachers: Issues and Challenges

New skill requirements for employment in the field of science and technology have made it critical that students demonstrate proficiency in science (Naizer et al., 2014). Students in middle school seem to be particularly vulnerable for failing grades in mathematics and science (Naizer et al., 2014; Wang et al., 2014). Several factors including low motivation, low academic engagement, and lack of confidence have been cited as being implicated in failure in science among middle school students. While middle school students' performance in all areas seems to be compromised, there is a markedly more pronounced decline in STEM performance among middle school students than in other academic areas (Naizer et al., 2014; Wang et al., 2014).

Middle school students are particularly vulnerable because of the challenges associated with transitioning from elementary to middle school. While this transitioning is occurring, middle school students are also first learning to manage emotional and physiological developmental changes that affect their self-confidence, perception of their ability, and consequently, their motivation, and academic performance (Naizer et al., 2014; Wang et al., 2014). Understanding developmental landmarks and how they affect learning is important for teachers. Furthermore, understanding cognitive skills and how these skills are applied in the process of learning science is also important for educators in developing and designing strategies that optimize students' ability to learn science (Nevo & Breznitz, 2013; Rhodes et al, 2012; St. Clair-Thompson et al., 2012; Stevenson et al., 2014). Educators can use the knowledge relating to those aspects of cognition that are critical to learning science to develop educational strategies that target these brain processes to optimize the learning experiences for students in middle school.

Foundational science knowledge. Given the implications of science learning to individual academic success, low proficiency in science education becomes a matter of critical concern (Diamond, 2013; Nevo & Breznitz, 2013; Rhodes et al, 2012; Rhodes et al., 2014; St. Clair-Thompson et al., 2012; Stevenson, 2012; Stevenson et al., 2014). One of the challenges facing science teachers in middle school is the lack of scholastic preparedness in students entering middle school (NRC 2012, 2013; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale, Hoffman, & Paciga, 2013). The foundational knowledge that adolescents bring to their learning experience in science hinge on the skills that they acquire in the learning experiences they encounter in their earlier years (Hoffman et al., 2015; Schickedanz & Collins, 2013).

Legislative and policy challenges. Elementary teachers should focus on conceptual skills that are foundational skills upon which later science education is built. However, due to the No Child Left Behind Policy (NCLB, 2002), elementary schools tended to shift their focus to content and subject areas other than science education

(Hoffman et al., 2015; NRC, 2012, 2013; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale et al., 2013). Due to this policy, students did not receive the educational experiences that fostered the development of foundational academic knowledge and cognitive skills required to achieve proficiency in science in middle school (Hoffman et al., 2015; NRC, 2012, 2013; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale et al., 2013).

The NCLB (2002) policy established benchmarks that focused on literacy and mathematical skills (Hoffman et al., 2015; NRC, 2012, 2013; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale et al., 2013). Schools were assessed based on students' performance. As such, teachers were pressured into focusing on benchmark skills that would assure the students performed well in key subject areas. Teachers were encouraged to integrate science into their reading programs where the central focus was literacy skills as opposed to content knowledge and conceptual frameworks that were specific to science (Hoffman et al., 2015; NRC, 2012, 2013; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale et al., 2013).

The focus on literacy skills resulted in the preponderance of informational texts being used in elementary schools (Hoffman et al., 2015; Yopp & Yopp, 2012). These texts did not always integrate science information in a manner that facilitated the development of conceptual constructions or the development of critical thinking skills within the context of science. As such, students were not adequately prepared to manage the benchmark requirements to attain proficiency in science when they enter middle school (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Hoffman et al., 2015; Yopp & Yopp, 2012).

Another policy change was the development of the Next Generation Science Standards (NGSS, 2013), which was drafted under the auspices of 26 states, the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), and the National Research Association (NRA). The purpose of the NGSS was to develop new education standards rich in both content and practice and aimed at developing benchmarks congruent with international standards based on three dimensions of science learning (NGSS, 2013; Penuel et al., 2015). NGSS (2013) was designed to increase students' proficiency levels and to develop a common standard for teaching and learning science across all states and schools. The standards set forth included core scientific concepts, benchmarked skills in understanding the scientific process of developing and testing ideas and increasing students' abilities to analyze and evaluate scientific evidence (NGSS, 2013; Penuel et al., 2015). Application of NGSS in teaching helps to transform science teaching practices that integrate core concepts, knowledge components, processes, and practical application to enhance the learning experiences of science students (NSCC, 2013; Penuel et al., 2015).

Highly qualified teachers. Amrein-Beardsley (2012) explained that policy makers feel that to improve students' achievement there is need to build on the quality of teachers in all classrooms. There is a struggle when it comes to a solution on how to provide highly qualified teachers as mandated in NCLB (2002) (Lochmiller et al., 2012). Lochmiller et al. (2012) concluded that because there is a need for improvement in math and science instructional leaders, principals can improve the outcome of success by collaborating with teachers in these content areas.

Inadequate professional development. Teacher proficiency in content delivery is an important element of effective science education (Bender et al., 2015; Heller, Daehler, Wong, Shinohara, & Miratrix, 2012; Penuel et al., 2015). Teacher proficiency, though critical, is challenging, and therefore, there is a need for teacher support to assist them in effectively implementing curricula, teaching practices, and strategies to meet the aims and goals established as benchmarks for science proficiency among their students (Bender et al., 2015; Penuel et al., 2015).

The rapid growth in science and technology has resulted in exponential growth in new information that continues to increase every day (Ahmed, 2013; Aslan, 2015; Partnership for 21st Century Learning, 2015). The rapid growth in technology has also placed greater demands on teachers and the quality of students who are entering the job-market. Science teachers are now required to be a depository of a vast array of content that is increasing in volume every day (Ahmed, 2013; Aslan, 2015; Partnership for 21st Century Learning, 2015). Scientific and technological development is occurring exponentially, and new materials are being made available daily. The rapid change of technology may present a challenge for teachers to keep abreast with the proliferation of new materials (Ahmed, 2013; Aslan, 2015; Fougner, 2012; Partnership for 21st Century Learning, 2015).

For many years, the quality of science teachers has been below standard, simply because of various barriers faced in the education sector (NGSS, 2013). For instance, in-service training programs aimed at enhancing the creative teaching skills of science teachers have been insufficient (NGSS, 2013). This inadequacy has contributed to many science teachers repeating the same teaching plan for multiple periods (NGSS, 2013; Penuel et al., 2015). The noted insufficiency has been a key obstacle toward the science performance in many schools across the country. With low in-service training programs, many science teachers have become inefficient when it comes to the preparation of the creative activities that stimulate creative thinking (NGSS, 2013; Penuel et al., 2015).

Traditionally, science teachers have been attending professional development courses intended to enhance science-teaching methods (Bender et al., 2015; Heller et al., 2012; Penuel et al., 2015). However, despite increased teacher attendance for these courses, many teachers still struggle in developing creative science teaching skills (Bender et al., 2015; Heller et al., 2012; Penuel et al., 2015). The shortfall in developing effective science teaching strategies results from the courses they normally attend solely focus on general teaching methods, and do not target address specific creative science teaching skills. The limited scope of these courses and programs has left science teachers unable to employ a variety of teaching plans. Science teachers across the country adopt the same teaching method in every science lesson, as they are largely unfamiliar with different modalities (Bender et al., 2015; Heller et al., 2012; NGSS, 2013; Penuel et al., 2015).

Additionally, science teachers fail to follow up the new research and studies linked to modern teaching methods (Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012). Failing to engage in learning new teaching methods that increase teacher skills and effectiveness in content delivery might have made it difficult for science teachers to connect with their students, resulting in deterioration in the performance in the sciences across the country. Success in teaching and learning depends heavily on the teachers' experience, their proficiencies, pre-service as well as in-service training, instructor-learner's relationships, effectual use of instructional time and resources, and regular evaluation of students' success (Bender et al., 2015; Heller et al., 2012; NGSS, 2013; Penuel et al., 2015; Teo & Ke, 2014).

Teacher evaluations. Teacher evaluation is purported to be a measure to ascertain the efficacy of instructional methods and teaching strategies in improving students' performance and engagement (Hoffman et al., 2015; National Research Council [NRC], 2012, 2013a; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale et al., 2013). Teacher evaluations are sometimes based on standardized test results. Students' rating is another method for assessing the effectiveness of teaching practices and strategies that the teacher employs in the classroom (Hoffman et al., 2015; NSTA, 2014; Teale et al., 2013). Dresser (2012) suggested that low test scores reveal students' inability to understand the content knowledge. However, when students receive test scores or poor grades, their negativity toward the subject as well as toward their teachers increase (Dresser, 2012). With increased negativity of students toward science, teachers may be the victim of circumstances. Given that teachers' evaluations are related to students' performance, the likelihood increases that students will end up rating their teachers poorly due to the negative attitude toward sciences (Dresser, 2012). If not controlled and adequately regulated, test-based teacher evaluation and sanctions may cause discouragement among science teachers (Dresser, 2012).

An approach with less reliance on test scores is the best approach in science in science education. Childs, Sorensen, and Twidle (2011) reported alternative assessments have been found to improve teachers' effectiveness while at the same time identifying the differences in teachers' effectiveness. Teacher practice could be evaluated using systematic observation protocols with well-developed, research-based criteria (Hoffman et al., 2015; NRC, 2012, 2013; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale et al., 2013). With these measures the use of observation, videotapes, lesson plans, and samples of student work are best practices for evaluation of science teachers (Hoffman et al., 2015). Using several measures to observe teaching practices facilitated identification of the most effective strategies that can lead to improvement in student understanding over a given period in relation to instructional methods and strategies. A variety of measures also helped pinpoint which methods and strategies can be used to increase students' engagement and academic performance (Hoffman et al., 2015; NRC, 2012, 2013; NSTA, 2014; Next Generation Science Standards Lead States, 2013; Teale et al., 2013).

Student engagement and motivation. Student engagement is optimized when teachers use active learning strategies, such as short tasks for small groups, relatable interests, and a collaborative process (De Naeghel, 2012; De Naeghel,Van Keer, Vansteenkiste, & Rosseel , 2012: Kell & Lubinski, 2013; Lin-Siegler, Ahn, Chen, Fang, & Luna-Lucero, 2016; Raes & Schellens, 2015; Rhodes et al., 2014; van Loon, Ros, & Martens, 2012). Student motivation is heightened when lesson plans include informational and fictional genres, such as science fiction. The effort of teachers to create interesting lessons increases motivation, which in turn can have a positive effect on academic achievement (De Naeghel, 2012; De Naeghel et al., 2012; Lin-Siegler et al., 2016). In the field of education, high-quality leadership can be instrumental when implementing innovative learning activities that perpetuate student engagement (Sato, Bartiromo, & Elko, 2016). Educators who exhibit the demonstrated leadership prowess may find it useful when facilitating science curriculum and assessing student understanding (Sato et al., 2016).

Several studies have indicated a decrease in students' motivation in school (Raes & Schellens, 2015; van Loon et al., 2012). Students' motivation is positively related to academic engagement and academic success (De Naeghel, 2012; Raes & Schellens, 2015). However, motivation continues to decline among students as they move from elementary to high school. Furthermore, motivation for learning science declines more steeply than other subject areas. Consequently, students' motivation for learning science tends to be lower than other subject areas and this decline is also more pronounced as students move from elementary through middle and high school. Therefore, one of the problems educators face is learning how to increase motivation for learning science. Motivation to learn science may be a challenge that is more pronounced in higher grades than in elementary school (De Naeghel, 2012; De Naghel et al., 2012).

Motivation for learning is a demonstrated action that is influenced by external and contextual factors (De Naeghel, 2012; De Naeghel et al., 2012: Raes & Schellens, 2015; van Loon et al., 2012). Motivation and school engagement are determined by both intrinsic and extrinsic factors. Given that external factors could increase motivation to learn science, approaches to increasing motivation to learn science should explore those contextual elements that influence science learning. Instructional methods and experience are among those contextual elements that have been associated with motivation to learn science (De Naeghel, 2012; De Naeghel et al., 2012: Raes & Schellens, 2015; van Loon et al., 2012).

Measures that titillate curiosity and create challenge are among the approaches that could be applied to increase motivation among students learning science (De

Naeghel, 2012; De Naeghel et al., 2012). Previous studies have shown that variations in individual cognitive skillsets are indications of the student's affinity to science, so that students who are more proficient in visuospatial skills have been shown to be more highly motivated to learning science (Kell & Lubinski, 2013; Rhodes et al., 2014). As such, measures to increase motivation to learn science should aim at integrating the contextual elements that relate to the pedagogical approach in science and the intrinsic cognitive skills and abilities that would promote science learning (De Naeghel, 2012; Raes & Schellens, 2015; Rhodes et al., 2014; van Loon et al., 2012).

In seeking to design an intervention model that would address issues of poor performance in science as it relates to motivation, Raes and Schellens (2015) engaged in a quantitative study of 220 students in 13 secondary science classes using a mixed method approach. Raes and Schellens posited that motivation is a factor of self-determination. Self-determination comprises elements that promote need satisfaction, which in turn would lead to self-actualization. Three elements, autonomy, competence, and relevance, were identified as being essential for need satisfaction (Raes & Schellens, 2015). As such, teachers, who engage students in learning experiences that promote autonomy, competence, and relevance would promote needs satisfaction that would lead to self-determination, thereby increasing motivation (Raes & Schellens, 2015).

Some studies have explored traditional elements that impinge on motivation and engagement as elements responsible for poor performance in science among middle school students (Naizer et al., 2014; Wang et al., 2014). One element is class size. Student engagement is challenging in larger classes because teachers need to employ extraordinary observation skills that ensure students are engaged with the course content.

Classroom environment. Generally, teachers govern the mechanics of classroom preparation, including their relationship with the students, course content itself, and how the content is facilitated. As cited by the Student Engagement Core (SEC) model (Dresser, 2012), if the learning environment reflects a positive teacher-student relationship, and students distinguish relevant content matter, and recognize teacher knowledge and ability to impart this information, student engagement is heightened (Brickman et al., 2013; Dresser, 2012). Simply put, when students display a passion for learning, and commitment to invest time, energy and creativity needed to accomplish goals, academic success is enthusiastically realized (Brickman et al., 2013).

Curriculum, materials, and equipment. From the body of literature, it is evident that schools are facing many challenges, particularly in the teaching of sciences (Trees & Jackson, 2013). Science learning has been shown to relate to cognitive abilities associated with language, reading, and communication skills (Kell & Lubinski, 2013; Rhodes et al., 2014). As such, curriculum materials and academic texts should be designed to ensure readability ease and to build on previous knowledge in a systematic and organized manner (NRC, 2013; NGSS, 2013; Penuel et al., 2015). Additionally, the NGSS (2013) posited that science education should provide learning experiences that integrate knowledge and practice. However, Penuel et al. (2015) reported that based on their analysis of existing curriculum materials there is an absence of curriculum materials that support an integrated approach to science learning.

For a long time, science teachers have faced barriers related to navigating their curriculum (Hechter, 2011). For instance, inadequate laboratory equipment limits practical, hands-on learning, which has a negative impact on student mastery of science concepts (Trees & Jackson, 2013). Inadequate laboratory equipment may reduce the amount of hands-on learning forces the teachers to return to a lecture format, thus reducing student engagement (Hechter, 2011). For example, rather than seeing lab results and experiencing more in-depth science knowledge, students are required to engage simply in memorizing facts to pass exams (Crawford, 2013). Yet, Crawford (2013) observed that true science learning does not call for simply memorizing but engaging with the concepts to promote in-depth understanding.

Technology can even be a help when adequate lab equipment is missing (Bianchini & Solomon, 2013). Videos of lab activities are available and showing these to students can provide some insight and better understanding of the science concepts than mere memorization and lecture. While videos cannot replace the value of actual hands-on lab experiences, this is an example of how technology can enhance the effectiveness of common problem of inadequate science equipment (Bianchini & Solomon, 2013). Brígido, Borrachero, Bermejo, and Mellado (2013) stated that with adoption of ICT technologies such as video media and other relevant technologies such as subject programming, teachers have a chance to initiate inspiration to students in a manner that are reflected in enhanced performances in these subjects.

Using technology to access this vast store of science knowledge is one of the options that science teachers could employ to meet the challenge of being up-to-date with science information (Dogru, 2013; Fougner, 2012; Roland & Martin, 2015; Roscoe, 2014; Suvannatsiri, Santichaianant, & Murphy, 2015). Although there are new media that employ electronic data sources where this vast store of science and technology information could be accessed, lag in technology availability at the institution level presents a challenge for both teachers and students in accessing content materials in science. The absence or paucity of technology at the institutional level that could and should be integrated in the science education process reduces teacher efficacy and proficiency in relevant scientific information that could be used to make science education more meaningful for students (Dogru, 2013; Fougner, 2012; Roland & Martin, 2015; Roscoe, 2014; Suvannatsiri et al., 2015).

Teaching strategies. To facilitate learning teachers must inspire their students to learn and to like studying sciences (De Naeghel, 2012; De Naeghel et al., 2012; Kell & Lubinski, 2013; Raes & Schellens, 2015; Rhodes et al., 2014; van Loon et al., 2012). Teachers must come up with unique teaching strategies that will be more appropriate to students than the traditional, long lectures that mostly put off the students. Unique teaching strategies may involve quality time, energy, and resources spent on activities designed to enhance learning motivation and to promote student engagement. Ivey and Johnston (2013) noted an increased level of engagement among some middle-school aged students. Ivey and Johnston explained that these students are becoming more interested in future endeavors, which may include higher learning and careers.

To be effective, teachers need to have a realistic view of their capabilities to impart knowledge and enthusiasm to learn. Ultimately, self-evaluation and confidence may influence successful learning outcomes for their students. White and Kline (2012) asserted that teachers are inadequately equipped to facilitate content matters effectively, when they are unfamiliar with the text and community. The disconnect encumbers preparation, as well as student engagement (White & Kline, 2012).

Technology. Relevance of subject matter and the extent to which this relates to middle school students' engagement has been a matter of concern. Students who perceive their learning experiences to be relevant to their personal experiences demonstrate higher academic engagement, motivation, and successful performance in science (Naizer et al., 2014; Wang et al., 2014). Technological usage is one of the areas that could be used to increase relevance for middle school students (Naizer et al., 2014; Wang et al., 2014).

Middle school students have a high usage of technology, particularly in the arena of social media and tend to engage in higher usage of technology for this purpose when compared with their teachers. Middle school students use an array of gadgets that require a new set of skills. Consequently, there is a gap between technology usage among teachers and students (Wang et al., 2014).

Nevertheless, despite the high usage of technology among middle school students, there is an absence of integrating this usage of technology into the learning experiences of students (Wang et al., 2014). Kaiser and Wisniewski (2012) expressed a resounding concern with engaging learners through a lackadaisical response to 21st century technologies. Teachers have a unique responsibility to reinvent and redesign learning environments that are responsive to the needs of 21st century learners (Kaiser & Wisniewski, 2012). Technology usage could be used as a springboard in teaching science and technology. Teachers could use the same technology that students use as a teaching tool to establish relevance and to motivate students with the aim of engaging them in learning about the science and technology. Integrating the science and technology as subject matter is becoming an integral aspect of middle school students' experiences (Wang et al., 2014). Therefore, if educators persist in utilizing out-of-date teaching techniques, today's students will tune out and drop out. Emphasis should be placed on teacher capacity to implement such tools that impact learning, promote knowledge, and facilitate cognitive immersion of students in the learning process (Kaiser & Wisniewski, 2012).

A concerted effort to promote interactive classroom instruction and student engagement can be realized using innovative technology within the classroom. Using advanced learning material and tools enhances learning and may lead to higher standardized test scores (Lecocq, 2015). One-way teachers can use media to enhance science performance is to video record a demonstration of how to conduct experiments in the school laboratory (Irez, 2015). Thus, students will be able to easily relate with the activity, and better understand how to handle scientific concepts, which may also help the student handle a practical question during exams (Irez, 2015). Videos can help learners grasp firsthand information on how to go through a given activity in a science lesson. Through this, students will be able to register images in their minds on how to tackle a given scientific challenge in their future lessons (Enyedy & Goldberg, 2013; Irez, 2015). Additionally, the use of photos as well as recorded videos by teachers while in the classroom makes the aspect of learning and studying sciences more fun.

A change in teachers' approaches to teaching the sciences will help in breaking the boredom that engulfs science lessons in schools (Enyedy & Goldberg, 2013). Koballa, Glynn, and Upson (2012) suggested that carrying out scientific experiments helps in learning characteristics and concepts, thus the significance of such experimental activities during class should never be underestimated. This way, students feel more inspired and motivated to learn during science lessons (Koballa et al., 2012). Students are more motivated when they learn through watching films and other forms of media

(Koballa et al., 2012). For effective use of media in teaching sciences, teachers need to adequately prepare the lesson systematically to ensure the lesson is well organized (Irez, 2015). For application of media in teaching sciences to be effective, it must be investigated, carried out, evaluated and then improved upon according to the pupils' needs and learning objectives (Irez, 2015).

Technology has rapidly evolved and become part of the students' lives; thus, its integration in classrooms especially during science lessons improve performance. Raes and Schellens (2015) reported that engaged students tend to absorb and understand more, thus qualifying the use of innovative, interactive technology as a key method of science instruction. For instance, the use of personal response clickers during science sessions offers a simple blended way in which the teacher is able to generate an atmosphere of students' interaction, a factor that can simultaneously enhance critical thinking along with problem solving among groups and individual students (Hoekstra & Mollborn, 2011; Kaiser & Wisniewski, 2012).

Student Response Systems. Optimal receptiveness to learn and participate in academic activities can be accomplished through use of the Student Response System (SRS) or clickers (Kaiser & Wisniewski, 2012). An SRS is an individual remote-control keypad, designed with multiple-choice questions that are displayed on a screen. An SRS can be used from kindergarten through college, and, due to ease of use, may replace the paper and pencil response systems used in the past. Use of technology such as clickers and SRS systems enhances lesson planning and student engagement.

The adoption of clickers can help the teacher in identifying the areas of weaknesses among his students (Kaiser & Wisniewski, 2012). Through this method, teachers get immediate feedback on the students' understanding level of a given science concept. Teachers are able to engage in differentiated instructional strategies that address individual students based on their level of strengths and weaknesses, instead of collective assumption that comes along with the traditional ways of teaching (Kaiser & Wisniewski, 2012).

Sun, Martinez, and Seli (2014) asserted that lack of student engagement is one of the main problems associated with the use of traditional lecture format as an instructional method. Electronic feedback devices can be used to address such problems (Kaiser & Wisniewski, 2012). These devices provide an interface for relaying information, so contact made between the instructor and the learners, which is the basis for gauging the effectiveness of the entire process (Kaiser & Wisniewski, 2012). The tool uses inference-driven questions to induce the critical thinking process, and correlation of behavioral and emotional levels of engagement. However, because educational technologies are prone to rapid change, research concludes use of feedback devices such as polling tools that are not prone to changes provide innovative ways for educators to encourage desired student engagement and overall development (Kaiser & Wisnieski, 2012).

Student-centered pedagogy. Efforts to implement a pedagogical process for programs such as STEM engage a much-desired personal interest and enthusiasm for career endeavors (Brickman et al., 2013). When creating an environment that enhances learning opportunities and engagement, teacher proficiency must exceed content knowledge (Brickman et al., 2013). Pedagogical skills are essential to facilitating subject matter in a comprehensible manner. Brickman et al. (2013) noted the relevance of associating subject matter with a student's personal interest, which contributes to a more engaged focus. Student-centered pedagogy and the use of inquiry-based approaches to instruction, encourage the students to hypothesize their own understanding of basic concepts. Gningue, Peach, and Schroder (2013) agreed with the fundamental objective of this approach, which is to develop student understanding of mathematics and science concepts. Watters and Diezmann (2013) stated that students understand how science and mathematics influence their everyday lives. Unfortunately, the connection was less notable among students in more developed countries. In fact, this study employs the importance of collaborative efforts involving STEM, the community, and educational leaders (Watters & Diezmann, 2013).

Classroom discourse. Sato et al. (2016) agreed that a positive teacher-student relationship is crucial. The positive relationship lends well to quality interaction and discourse. Smart and Marshall (2013) conveyed the importance of classroom discourse, particularly with emphasis on teacher questioning and student interest in science curriculum. As stated by Järvelä, Veermans, and Leinonen (2008), constructive correlations can be achieved through an operative classroom discourse that imposes the following measures: questioning level, complexity of questions, questioning ecology, communication patterns, and classroom interactions. Furthermore, such a concentrated effort gives teachers an excellent opportunity to develop student aptitude toward key science concepts, and critical thinking (Järvelä et al., 2008). When teachers are strategic with asking questions purposefully designed to facilitate higher cognitive levels, the reasoning process reinforces relevance of scientific notions and student engagement (Smart & Marshall, 2013). Other theorists concurred that students strengthen both written and oral expression, as derived through reasoning techniques and justification processes

(De Naeghel, 2012; De Naeghel et al., 2012).

Simplified approach. To inspire passion and curiosity toward science activities, teachers must model a total commitment for science (Timur, 2012). Teachers who present science curriculum through a simplified approach, which focuses on the common and familiar life challenges experienced by students, observe more focused engagement (Timur, 2012). Thereby, students' enthusiasm is readily exhibited because they recognize the relevance of the experiment (Rukavina et al., 2012). Therefore, it is vital to define students' perceptions and viewpoints toward the adoption and use of technological materials (Xie & Andrews, 2013). Xie and Andrews (2013) found students' expectation of assessments influenced their attitude toward teaching and learning.

Science Education: Globalization

Proficiency in science has implications for national development, quality of life, standard of living, and status among global powers (Brownell et al., 2013; Clark et al., 2016; Devonshire & Hathway, 2014; Pietri et al., 2013). Proficiency in science is beneficial to society in that it is a platform for technological innovation and change (Devonshire & Hathway, 2014). High proficiency in science is foundational to achievement of scientific breakthroughs that could impinge on the quality of life in many arenas, including health and biochemistry (Devonshire & Hathway, 2014; Pietri et al., 2013). Scientific breakthroughs and innovations could be applied in research and development for the benefit of society (Brownell et al., 2013; Clark et al., 2016). Consequently, a focus on proficiency in science is critically important for the continued development of the nation.

Science education becomes even more critical because of globalization, increased advancement in technological innovation ease of communication (Kelly et al., 2013). The Program for International Student Assessment (PISA) is an assessment system through which academic performance statistics among students in 32 countries and compared. Based on the PISA report, 9% of 15-year old students in the United States scored at a proficiency level in mathematics compared to 55% in Shanghai, China (Organisation for Economic Co-operation and Development, 2014). In science literacy, the PISA statistical report indicated 7% of US 15-year old students performed at proficiency level compared with 27% of students in Shanghai, China (Kelly et al., 2013).

The poor performance among US students when compared with other leading nations in the world has implications for the society and the economy at both the domestic and international levels (Carillo & Papagni, 2013; Kobold, Guhr, Kurtz, & Löser, 2015; Koosimile & Suping, 2015; F. Miller et al., 2015). Globalization has caused a greater level of integration among those nations that are leading in scientific and technological innovations (Koosimile & Suping, 2015). The integration presents promises of cooperation and challenges of competition (Carillo & Papagni, 2013; Koosimile & Suping, 2015).

Confidence and competency is derived from practicing target concepts and evaluating development. Monitoring individual growth is a critical aspect in attracting and retaining students (Wu, Mar, & Jiau, 2013). Thien and Razak (2013) stated, “As a response to the pressure of globalization and sophisticated technology development, schools need to be more flexible, creative, and responsive to meet the diverse nature of challenges that confront them in the 21st century” (p. 679). Current research infers an essential need for advanced tools and proficiencies to flourish in our global economy.

Implications

The review of performance in science is the key to the determination of the solutions that would bring significant improvement (Tedman, 2005). The purpose of engaging in this study was to develop an understanding of teachers' perceptions of why eighth-grade students have consistently failed to meet state-mandated standards in science curricula. The teachers' perspectives on the way that students construct their world and process their developmental and operational experiences impact science learning among middle school students (Brickman et al., 2013).

When teachers reveal the challenges of teaching science, stakeholders can begin to devise a plan used to implement new curricular ideas that will help students and teachers overcome those challenges and increase student achievement on assessments and in the classroom. Furthermore, suggestions made would be imperative in the improvement of delivery of the lessons. Proper learning as proposed would be the primary requirement if there is to be chance of attaining the anticipated objectives and improve the delivery of the lessons.

This study offers insight needed to improve science achievement, which can assist the targeted county with infusing new curriculum tools and strategies that support teachers in teaching science effectively. Future research projects that assess two groups, one group using the curriculum tools and concepts in science education that emerged from this study, and a control group not using this study's curriculum tools and concepts, might be useful in testing the efficacy of the outcomes from this study.

Summary

In-depth research data and proactive efforts to address eighth graders' poor academic performance in science was important at Peach Middle School and Pear Middle School. The failure in science by eighth-grade students has necessitated the need to review some of the typical triggers of the underperformances (De Naeghel, 2012; De Naeghel et al., 2013; NGSS, 2013; Penuel et al., 2015). The key factor is that understanding science is at the forefront in determining the effectiveness of the teachers and teaching strategies that would increase students' engagement (Cervetti et al., 2012; Raes & Schellens, 2015; Rukavina et al., 2012). The modalities of teaching employed by the instructors are important contextual elements that help to determine the retention capacity of the leaners (Hoffman et al., 2015). Practices used to improve student engagement and learning also impact their applicability of the concepts learned (NGSS, 2013; Penuel et al., 2015).

The methodology that was used in this study will be presented in Section 2. I will describe the qualitative research approach that was best suited for the study, and describe the participant selection and the ethical measures taken for participant protection. Finally, the next section will include a description of the data collection and data analysis process.

Section 2: The Methodology

Qualitative Research Design and Approach

The purpose of this study was twofold. The main goal was to obtain teachers' perceptions of the challenges of teaching science to middle school students at Peach Middle School and Pear Middle School, specifically related to how they apply what they learn to their everyday experiences. The second goal was to determine which developmental and operational learning characteristics science teachers identify as affecting achievement of proficiency in science education. To address the purpose of the study, I used a qualitative research design to explore teachers' perceptions of why eighth-grade students have consistently failed to meet state mandated standards in science. A qualitative design was also applicable in examining the challenges teachers experience when instructing science curricula to middle school students. Research findings may provide sustainable data that will help teachers and administrators proactively address poor performance in science.

A qualitative research design was the most appropriate approach for this study because, as Merriam (2009) and Patton (2002) noted about qualitative research, it focuses on understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences. In this study, my goal was to gain insight into the way that science educators perceive their own teaching experiences and their students' learning experiences within the context of the school environment. Patton indicated data from document review and open-ended interviews can allow a deeper probing into the perceptions of the participants, thereby resulting in an increased understanding of the participants' experiences in a real-world setting, which in this case was in two middle schools.

Research Design

Qualitative research methodology takes many forms or designs. One of these designs is case study. According to Bogdan and Biklen (2007), "A case study is a detailed examination of one setting, or a single subject, a single depository of documents, or one particular event" (p. 59). A case study design gives an orderly view of a single contemporary phenomenon in real life (Hancock & Algozzine, 2011; Tetnowski, 2015; Yin, 2009). According to Yin (2004), a case study design allows a researcher to examine a case in an in-depth manner "within its real-life context" (p. 3). Yin (2003) noted that case study inquiries cope with "technically distinctive situations" where there are many "variables of interests and only one data point and result" (p. 27). A case study of two middle schools in one district provided opportunity for investigating teachers' perceptions of the reasons for poor performance in science by eighth-grade students.

Other qualitative research designs include phenomenology and ethnography. Case studies differ significantly from phenomenological approaches (White, Drew, & Hay, 2009). According to Merriam (2009) "phenomenological research is well suited for studying affective, emotional, and often intense human experiences" (p. 26). Phenomenological studies are concerned with individual meaning as an important element of human experience, whereas the focus of a case study is to uncover and understand participant cognitive processing (Glesne, 2011). Furthermore, case study design also differs from ethnography.

> Ethnography is actively situated between powerful systems of meaning. It poses questions at the boundaries of civilizations, cultures, classes, races, and genders.

> Ethnography decodes and recodes, telling the grounds of collective order and diversity, inclusion and exclusion. It describes processes of innovation and structuration. (Hooks, 1990)

Willis (2007), acknowledging the similarities between case study approaches and ethnographic research, argued that the culture component of ethnography delineates case studies from ethnographic research. Ethnography is storytelling that describes situations based on the perceptions of the participants within their contextual experiences. The current study explored why eighth-grade students are performing poorly in science. Case studies are used to focus on the *how* and *why*, which was most appropriate for this study.

As stated by Stake (1995), “the two principle uses of case study are to obtain the descriptions and interpretations of others” (p. 64). Data collection for this study involved the use of interviews and document review. The interviews elicited the science teachers’ descriptions of their perceptions of the phenomenon and reasons for occurrence. The document review included a variety of documents such as assessment data, curriculum guides, science websites, and the Georgia Department of Education (GDOE) website. One of the key advantages of case studies, compared to these other methods, is the applicability to many situations.

The versatility of this research design is suitable to study situational occurrence, where other approaches may fail. The research questions for this study were focused on identifying the different perceptions of teachers about teaching science and about student achievement in this subject. As Yin (2003) indicated, with the need to explore the perceptions of individuals, a case study is indeed an appropriate design, which applied to this study. Moreover, as the researcher, I had to focus on exploring a phenomenon, the ability of students to meet state-mandated standards in science curricula. Yin claimed that a case study is appropriate for research that has unclear boundaries and requires in-depth exploration of data. Because of the scope or system of interest for this study, which has unclear boundaries, a case study is further established as the appropriate design for this research. In this study I focused on an actual circumstance and environment, which Yin (2009) noted are best investigated through a case study design. A case study of two middle schools in one district provided opportunity for investigating possible reasons why eighth graders at these schools are not meeting science standards.

Participants

In this research study, I focused on two schools within the targeted county. The participants were teachers who were selected from the 2017-2018 school year. Following Patton's (2002) information, I used purposeful sampling to choose participants for this study. Patton (2002) addressed the strengths and weaknesses of purposeful sampling by emphasizing what would be bias in statistical sampling, and therefore a weakness, becomes intended focus in qualitative sampling. The logic of purposeful sampling is in the choosing of information-rich cases from which the researcher can learn a great deal (Yin, 2009).

Eligibility Criteria

I selected 12 participants from the targeted middle schools. I interviewed five science teachers from Peach Middle School and five science teachers from Pear Middle School. Two additional teachers submitted responses in writing, preferring that method rather than participating in face-to-face interviews. Because the sampling technique was purposive, I used a set of eligibility criteria to determine if a teacher was an appropriate participant for this study. The teachers included in this study: (a) were teaching earth, life, or physical science; (b) and must have had a minimum of 3 years of experience teaching science in the middle grades. The participants ranged from 3 to 20 years of experience teaching (See Figure 1).

Merriam (2009) indicated that participants' professional experience and curricular knowledge would provide additional insight, which proved true for this study. The variations in their years of teaching experience added depth to the data collected. The number of participants was manageable and assisted me in thoroughly examining the issues surrounding the students' performance in both middle schools. Guest, Bunce, and Johnson (2006) stated that saturation occurs with approximately 10 participants in homogeneous groups. Furthermore, Crouch and McKenzie (2006) believed that less than 20 participants in a qualitative study helps a researcher build and maintain close relationships with the participants.

Justification for the Number of Participants

In case studies, "sample selection occurs first at the case level, followed by sample selection within the case," (Merriam, 2009, p.82). Generally, due to the massive amounts of data collected when conducting a case study, a case should not include more participants than can be richly explored by the researcher (Yin, 2009). The generally prescribed basis for identifying the sample size for a qualitative case study is the point of data saturation (Malterud, Siersma, & Guassora, 2016; Tran, Porcher, Tran, & Ravaud, 2017).

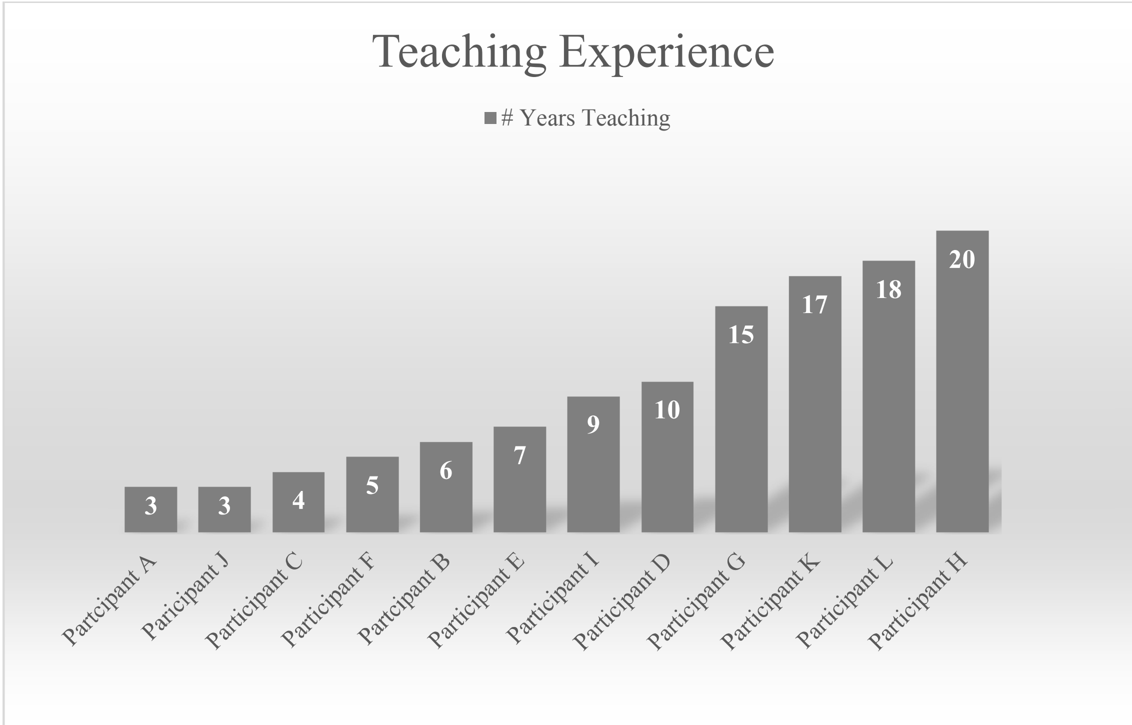

Figure 1. Years of participants' teaching experience

Data saturation point refers to an instant during data collection when the data collected has reached the optimal size, wherein the addition of new data will not yield significant difference in the number of unique codes and code frequencies (Tran et al., 2017). According to Yin (2003), a sample of at least six participants is enough for a case study to reach data saturation, provided the attributes of the participants are aligned with the requirements of the study. I chose an initial number of 12 participants to participate in this study, 10 of whom completed face-to-face interviews. Two additional participants opted to submit in writing their responses to the interview questions, rather than complete a face-to-face interview. The sample size was enough for me to reach data saturation. However, had I not reached data saturation, I would have interviewed additional science teachers from the targeted middle schools. If the additional participants had not wished to participate, I planned to reinterview the original participants using additional questions.

Procedures for Gaining Access to the Participants

The process of gaining access to the participants involved preapproval from school principals and the district. I submitted to these offices preliminary requests for permission to conduct the study with 10 science teachers. I received permission from principals and approval from the district. Following preapproval from the building principals and district, all the relevant information was submitted to Walden University's Internal Review Board (IRB). After receiving IRB approval, designated as IRB approval number 11-03-17-0306675, I set appointments with school administrative personnel and department leaders to discuss and develop an appropriate and effective participant recruitment method.

Recruitment methods included face-to-face contact, as well as using school websites, departmental bulletin boards, and emails to invite teachers to volunteer to participate in the study. Participants were provided with details of the study in the consent form approved by Walden's IRB. Information concerning confidentiality and ways to contact me to initiate their participation in the study were also provided. Participants were informed of the voluntary nature of their involvement and their right to terminate their involvement at will. Participants had 1 week to submit written consent forms to me. I verbally let each participant know the day and time that I was available to collect consent forms in the administrative conference room in each targeted middle school. After receiving the signed consent forms from the participants, I scheduled appointments to conduct the interviews with the participants at a time that was mutually convenient.

Methods of Establishing a Researcher-Participant Working Relationship

Boström, Yacoub, & Schramm (2010) recommended researchers to establish working relationships with participants prior to beginning a study. To that end, I established researcher-participant working relationships before the study when I met with the participants. I spoke with the participants individually during their planning period for 20 minutes. I informed them about the rationale of carrying out the study and how the study may help them and their students. After the consent from participants was received, I sent participants my email and they responded with a day and time to schedule their interviews. The interviews took place in conference rooms at Peach Middle School and Pear Middle School. After participants responded through email regarding a day and time for their interviews, I replied to their emails confirming days and times. Scheduling one-on-one meetings to conduct the interviews during planning period's ensured participants were available and instructional time was not interrupted.

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Measures for Ethical Protection

Ethical issues arise in qualitative studies and the researcher should anticipate and handle them accordingly (Creswell, 2013). I followed ethical guidelines set forth by Walden University to protect participants and ensure accuracy in the study. It was my responsibility to protect the participants, the research site, and the data collected with the study. To protect the participants, I gave a copy of an informed consent to each teacher who was part of the data collection of the study. Through the consent process, the participants were allowed to give an informed decision about being part of the study. The consent forms included information about the scope of participation and possible risks involved in being a respondent to this research. Moreover, participants were assured of the confidentiality of their names, and I assigned alphanumeric identifiers as pseudonyms instead of using the real names of the teachers and the school where they work. In this manner, I was able to protect their identity and maintain confidentiality.

Finally, I made sure that all data sheets and information files used for this study were stored in a locked cabinet. I secured all transcriptions of interviews in a locked file cabinet in my home. Protection of the participants was enhanced through the assurance of confidentiality to maintain their contact information, using alphanumeric identifiers to protect their data, and asking for their informed consent before engaging them in the research process (Boström et al., 2010). All collected data were stored in a password-protected computer. I am the only person with access to these data and files. I will keep all the data for five years before I will burn or permanently delete these files from the storage space. There was no physical or mental harm caused to participants. Moreover, participants did not have to answer any research question they were uncomfortable answering. Two of the participants wanted to complete the interview questionnaire by submitting their responses in writing. These participants completed the questionnaire and placed their written responses in a yellow envelop inside the teachers' mail room. When data were transcribed, all participants had an opportunity to review the data used in the findings to ensure the data were accurate.

Data Collection

Preparing for data collection includes: exercising good listening skills, asking questions that will render the best responses for the phenomenon studied, and avoiding biases (Yin, 2009). The data collection instruments used for this study were open-ended interviews and document review. The case study design relies on the use of multiple sources, which assist the data to come together in a triangulation technique (Yin, 2009). The use of interviews and documents were effective in helping to enhance understanding the of teachers' perceptions of why eighth-grade students are performing poorly in science. Moreover, with the interviews, I was able to collect in-depth data that directly addressed the research questions of the study. I was also able to confirm the validity of the interview data through document reviews.

Instrumentation

Interviews. Open-ended interviews were one of the data collection tools used in this study (Appendix B). The interview questions, aligned with the research questions guiding this study project, were developed with the assistance of two professionals from the school where I was employed at the time of the study, which was not one of the schools where data were collected. These two professionals had at least seven years of teaching experience and were science department chairs. Also, I had members from my doctoral committee review questions for clarity and relationship to conceptual framework. The purpose of the science teacher experts and doctoral committee was to ensure that the data collection tool was clear and pertinent to science. I validated the interview protocol by aligning the interview questions with the research questions using a design alignment tool. The design alignment tool matched each research question with the instrument used to collect the data and the specific questions within the instrument that addressed each research question. A sample of this design alignment is provided in the Bracketing Template in Appendix C.

Interview questions one and two are aligned with the first research question in probing for teachers' perceptions of challenges of teaching science to eighth-grade students and how their students relate what they have learned to the world around them. Furthermore, interview questions three, four, and five focused on developmental and operational learning characteristics viewed by science teachers as affecting the achievement of proficiency in science learning.

Open-ended interviews were used to collect data on the perceptions of science educators regarding the academic performance in science among eighth-grade students. I used an interview guide to ensure best interview procedures are used (McNamara, 2009). Jacob and Furgerson (2012) listed tips to follow when conducting an interview: (a) use a script; (b) collect consent; (c) use a recording device and take brief notes; (d) arrange interviews in a quiet, semi-private place; and (e) be sure interviews are allotted enough time to avoid interruptions. The interview questions related the teachers' perception of students' lived experiences and the applicability of science learning to how students construct their world (Bianchini & Solomon, 2013).

Documents. Document review was another data collection tool used in this study. Documents provide information that may have occurred before the study began (Patton, 2002). Data were gleaned from reviewing assessment data, the targeted district's curriculum guide, and the state board of education website. These documents provided information needed to assist in answering both research questions that pertain to teachers' perceptions of challenges of teaching science to eighth-grade students, and to the developmental and operational learning characteristics viewed by science teachers as affecting the achievement of proficiency in science learning. The review of documents also provided information about how students relate what they have learned to the world around them. The data from the document review helped to address the problem statement of why eighth-grade students from the targeted county are performing poorly in science. The curriculum guide helped to understand the state outlined objectives related to science and tools available to assist with teaching the science curriculum. Finally, document review data helped in validating the findings from the interviews through data triangulation.

The GDOE’s public website was referenced for all testing data for all schools within the targeted county, as well as for state-recommended science websites for teachers and students. The data helped in determining the progress of students in science in the targeted schools. The data collected included the eighth-grade science CRCT and state MST performance data and curriculum guides. The data collected from documents regarding the performance of eighth-grade students was cross-referenced with data collected using interviews (Merriam, 2009). Performance data assisted as I drew conclusions about the guiding questions (Boström et al., 2010).

Data Collection Procedure

Interviews. On the day of each interview, I made sure I arrived at least 15 minutes earlier than the scheduled time to prepare the material I needed. I waited for the participants to arrive. I began the interview five minutes after the participant arrived. I made sure the entire interview was audio-recorded from start to end.

I began by discussing the topic of the study and the flow of the interview. I then started asking questions based on the interview guide. After asking all the questions, I asked the participants if they had any questions for me about the interview or the study. I tried to answer all questions from the participants without providing any confidential information. I ended each interview by thanking the participants for their time.

Document review. After each interview, I collected the relevant data. When conducting the document review, I looked for texts that showed evidence about the challenges of teaching science to middle school students. Specifically, I highlighted information about the science curriculum offered and the progress of students in science subjects. Based on the information obtained from the review, I identified possible sources of challenge in teaching and learning science in middle school. Moreover, the information from the documents was used to validate interview data.

Role of the Researcher

I have been employed as a teacher for six years in the targeted district. During this time, I have managed to maintain a good rapport with colleagues. The researcher-participant working relationship was created through the provision of a free and fair process where the participants gave their opinions freely (Patton, 2002). My professional experiences, opinions, and thoughts may have affected the data collection process and interviews. However, I documented biases, including possible biases toward science education, curriculum, approach, and excluded negative attitudes toward gender, age, or disability (Chan, Fung, & Chien, 2013; Creswell, 2013). Also, I could have been biased toward science education. I used member checking, which gave the participants an opportunity to review their data used in the findings to ensure their data were accurate.

The opinions of the participants were respected (Cocco & Tuzzi, 2013).

I followed the guidelines that Creswell (2013) suggested for limiting biases when writing reports. “The researcher must be careful with the language used and this includes demeaning attitudes, biased assumptions, awkward constructions that suggest bias because of gender, sexual orientation, racial or ethnic group, disability, or age” (Creswell, 2013, p. 277). My biases are in regard to students’ expectations as related to tests. For example, in the targeted middle school, students do not have to pass standardized science tests; so, with this mind-set the students are not motivated, and they know there is no consequence for failing the science test. Furthermore, I am biased in my thinking regarding the causes of low academic performance in science education among eighth graders. My bias might have emerged out of required accountability for students’ performance. Nevertheless, findings from this study yielded information concerning the reasons for students’ low performance that might not be related to teacher performance or strategies. An assumption that learning is facilitated based on the way students construct their world and, on the students’, developmental and operational characteristics is fundamental to this study.

Data Analysis

I transcribed the data immediately following each interview. The sooner this process occurred following each interview, the more likely I was to remember and more accurately interpret nuances and non-verbal cues and responses that I included in my notes during the interview. Hand analysis of qualitative data were used. Data from the interviews was transcribed. I typed a transcript for each recorded interview using Microsoft Word. Two of the participants chose to answer the interview questions in writing instead of being recorded, so their typed responses were included in the composite data.

When transcriptions were complete, I engaged in a preliminary hand analysis of the data. According to Creswell (2013) “The hand analysis of qualitative data means that researchers read the data, mark it by hand, and divide it into parts” (p. 239). First, I organized the material based on the broad constructs derived from the theoretical framework. The interview questions were designed around these constructs. I reviewed the data and highlighted any common themes, ideas, concepts, or vocabulary that appeared several times in the documents. These themes were analyzed and interpreted within the framework of the theoretical constructs undergirding this study.

The most common themes identified in the data for the first research question addressing possible barriers to student engagement were: (a) lack self-motivation, and (b) negative attitude or behavioral issues. For the second research question addressing developmental and operational learning characteristics viewed by science teachers as affecting achievement in science, the common themes were (a) behavioral issues; (b) lack of concept application; (c) lack of intellectual development; (d) need for instructional strategies; and (e) need for professional development. When themes were determined then each of these themes was connected to the theoretical framework. The theoretical framework for this study can be divided into two categories constructivism and cognitive development. Constructivism in this study focused on the teachers’ experiences in teaching science to eighth graders and what they perceived about students’ attitudes toward science, which was identified in the data as positive, negative, or no motivation to learn science. Furthermore, cognitive development theory aligned with the data pertaining to lack of effective strategies, and interactive learning, which enhances student engagement and helps students' increases their concrete operational development (Ghazi & Ullah, 2015).

Next, I engaged in a peer review process. I solicited help from a peer in my doctoral program to review the finalized themes, and to review all findings based on data collection. Peer review helps to ensure that research findings are accurate (Creswell, 2013). The classmate has a doctorate degree in science and has 20 years of experience in the field of education. The peer reviewer signed a confidentiality agreement to protect participants.

Triangulation methods were used to check the credibility and the accuracy of the results. To achieve triangulation of data, I cross-referenced the participants' interview responses with the documents I reviewed. Triangulation involves the use of different data sources to increase accuracy and credibility of data and to confirm the findings of the study (Boström et al., 2010; Merriam, 2009; Patton, 2002). According to Creswell (2013), when using triangulation, "The inquirer examines each information source and finds evidence to support a theme, which ensures the study will be accurate" (p. 259). Furthermore, Merriam (2009) described triangulation as using multiple methods of data collection. These methods of data included interviews and document review.

Creswell (2013) contended that discrepant cases may appear to be contradictory to the data collected; however, careful and appropriate analysis of discrepant cases is valuable and may enhance the findings of the study. Careful analysis of discrepant cases, redefining and broadening the interpretation to accommodate and include discrepant cases in the analysis may help to reveal unique patterns and perceptions that might be readily observed (Creswell, 2013). I dealt with discrepant cases when they arose. By including the necessary documentation needed to address the discrepancy, making sure I corrected or addressed the issues.

The final step in the analysis and triangulation process involved member checking, which is soliciting feedback on the findings from all of the teachers interviewed (Merriam, 2009). Once data were transcribed and themes and conclusions were identified, I sent all participants a copy of the findings and asked if they thought I accurately captured their ideas. Member checking was used to ensure the validity of the findings and to review interpretations drawn from the data collected. All participants were allowed to read the draft of the findings based on their responses and verify that their experiences and perceptions were accurately represented in writing. The participants had the opportunity to agree or disagree that I correctly summarized their responses and were given an opportunity to discuss the findings and their data with me, enhancing the accuracy of the study (Creswell, 2013; Maxwell, 2005).

Data Analysis Results

The case study method of data collection and analysis was employed in this research. The research design involved the selection of the schools based on their past and current performance as measured by Georgia's standardized science test. The schools were chosen because they performed poorly in sciences and did not meet the state's Performance Standards. The participants of the study were teachers because they have a deep understanding of the learning processes and the factors that contribute to students' poor performance in science. The qualitative methods of data collection involved the use of open-ended interviews and document review.

Results of the Study

A qualitative case study design was used for the exploration of teachers' perception of the reasons behind the failure of eighth-grade students to meet standards in science curricula as mandated by the state. The data were collected through open-ended interviews and document reviews. The documents reviewed included assessment data, curriculum guides, and the website of Georgia's Department of Education (GDOE). On the other hand, the interviews were conducted with 10 teachers of physical, earth, and life sciences, with two other teachers submitting responses to the interview questions in writing. The data were analyzed using hand analysis. The following themes related to the first research question regarding possible barriers to student engagement emerged from the data: (a) lack self-motivation; (b) negative attitude or behavioral issues; and (c) positive attitude or excitement (see Figure 2). Additional themes related to the second research question regarding teaching and learning characteristics were: (a) lack of intellectual development; (b) lack of concept application; (c) need for instructional strategies; and (d) need for professional development (see Figure 3). Document review

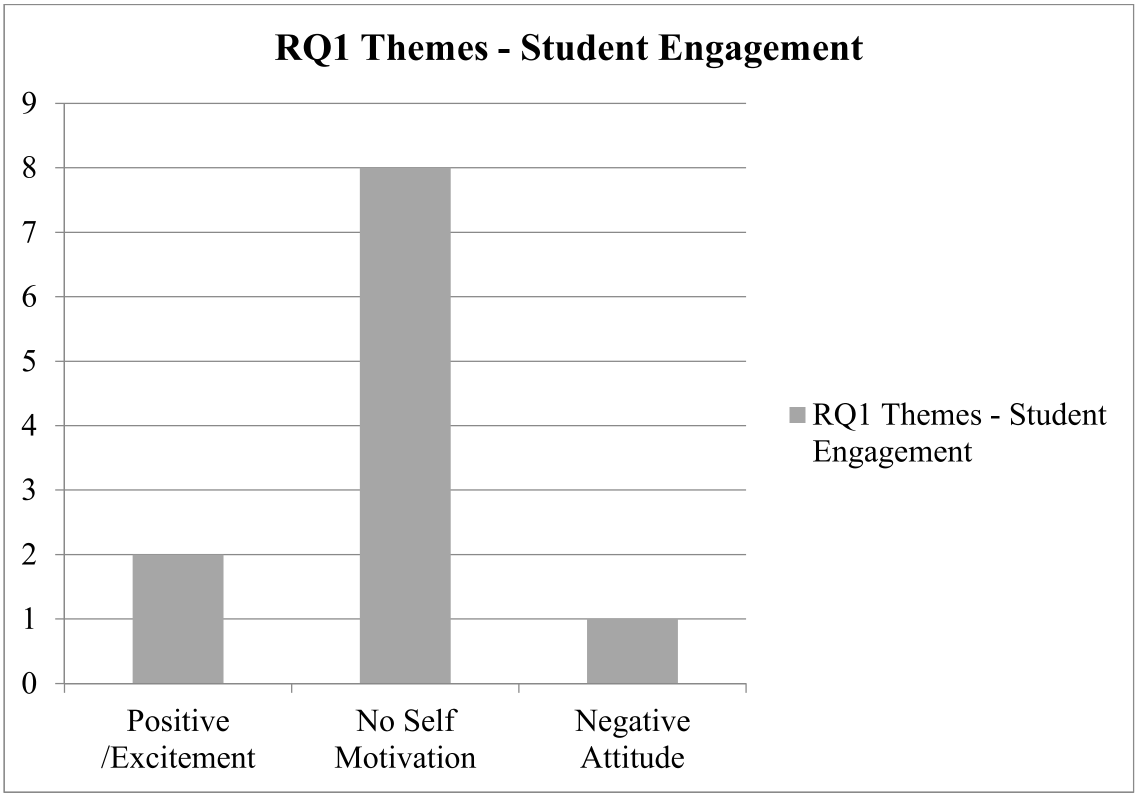


Figure 2. Themes related to Research Question 1: What are teachers' perceptions of challenges of teaching science to eighth-grade students and how their students relate what they have learned to the world around them?

data affirmed the common themes, specifically: (a) curriculum lacks interactive strategies; and (b) lack of intellectual development (as seen in lack of progress in science according to scores on test).

First, I sought to establish the perceptions of teachers as they pertained to the teaching of science to eighth-grade students and the way students relate the content of their learning to their surrounding world. Further, I sought to establish the perceptions of teachers as they pertained to the operational and the developmental characteristics that impact science learning proficiency. The results presented are the findings from the

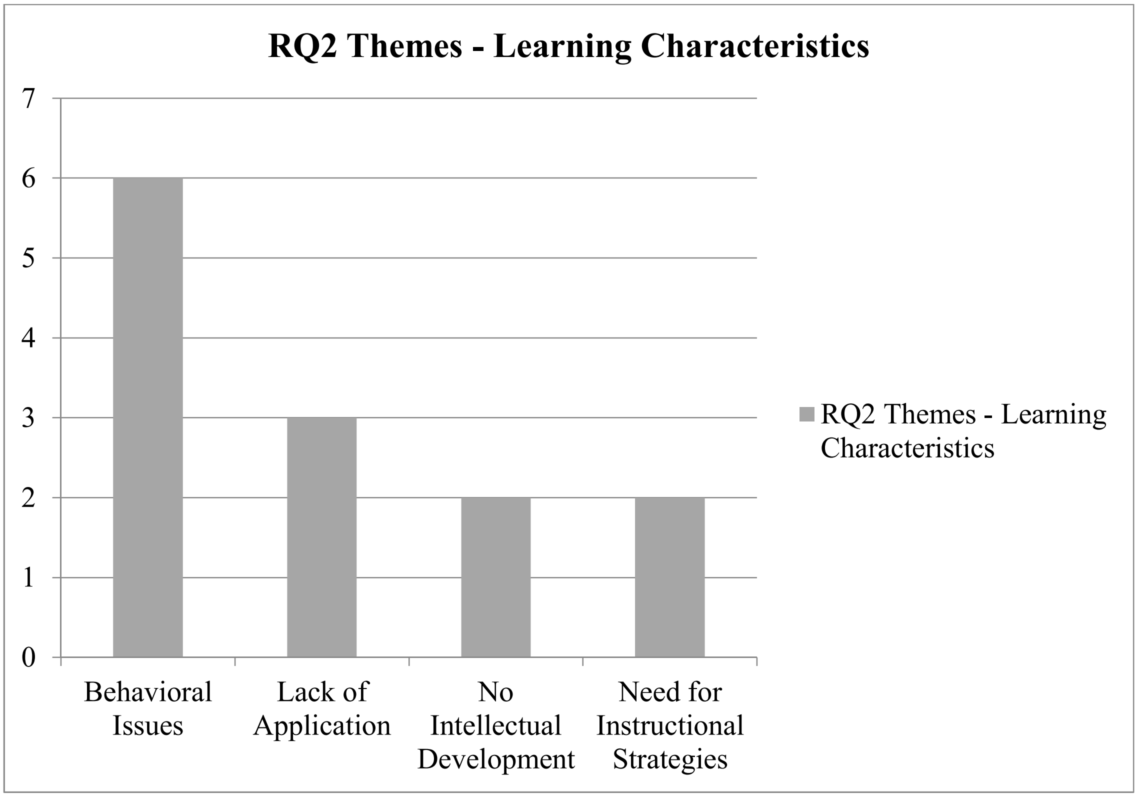


Figure 3. Themes related to Research Question 2: What developmental and operational learning characteristics are viewed by science teachers as affecting the achievement of proficiency in science learning?

interviews conducted, and documents reviewed. The themes that emerged from the first research question, asks teachers' perceptions of challenges of teaching science to eighth-grade students and how their students relate what they have learned to the world around them. These themes stem from teachers' perceptions of students' attitudes toward learning science and teachers' challenges toward teaching eighth-grade students science.

First research question. What are teachers' perceptions of challenges of teaching science to eighth-grade students and of how their students relate what they have learned to the world around them? The following themes were revealed from this data: Lack of motivation, and negative attitudes or behavior issues.

Lack of motivation. For the first theme, which is lack of motivation, evidence from the data showed that eight out of the 12 participants expressed that students lack motivation to learn the subject, which is a challenge for the teachers of eighth-grade science. Participant A stated that the students characterize themselves as someone who is not going to be successful with science from the very the beginning. Moreover, Participant C said if students are not interested in the subject, they would not be motivated to perform well in it. Participants F and G expressed that the lack of motivation in science is due to past experiences of students not being good at science. Furthermore, Participant J felt because of the lack of student engagement, the lessons would quickly transition to teacher-centered learning, as the teacher would give up waiting for answers that did not seem to be forthcoming.

Negative attitude or behavioral issues. For the second theme, which is negative attitudes or behavior issues, Participants A, C, and E, agreed that even when some of their students were excited about science and found it easy to remember some things that were discussed during the lesson, they did not spend time any additional time gaining a better understanding of the concepts taught in class, which is a sign of negative attitude or behavior. Participant A stated:

> Students are excited about science and they come in really liking it and typically those students can remember the lesson taught, however they don't know where they are actually trying to go with it. They aren't willing to put forth the effort needed to reinforce what they learned outside of school. They just like the process of science but they are intrigued by it but don't have an end goal.

Also, Participants C and E indicated some of their students were auditory learners, which helped them to be successful with recalling information discussed in class. Participants A and F mentioned that ease or difficulty of the subject depended on the different abilities of students. Participant F stated:

> Some students who are gifted in memory often found the subject not as difficult because they could quickly remember the concepts taught and would easily follow through experiments. However, they were unable to understand underlying concepts, therefore, failed standardized questions that require a demonstration of understanding and application as opposed to content memory.

On the other hand, Participants A, B, and D agreed, students who were able to operate at the higher level of thinking struggled with concepts they did not find fascinating, and therefore, lost interest in the concept being taught. Participant B stated, "If I can't connect the concept to robotics they were not interested." Moreover, Participant D stated, "When students could not easily remember facts and formulae, they easily gave up altogether."

Second research question. What developmental and operational learning characteristics are viewed by science teachers as affecting the achievement of proficiency in science learning? For the second research question, I explored the developmental and operational learning characteristics teachers thought affected the achievement of proficiency in science learning. The main themes were: (a) behavioral issues; (b) lack of concept application; (c) lack of intellectual development; (d) need for instructional strategies.

Behavioral issues. The theme of Behavioral issues is also prominent based on the data for five out of the 12 participants. Participant A expressed that if students were not interested in the topic, they did not want to participate, which is a significant behavioral issue. The lack of interest in the subject is a student characteristic that could negatively impact a students' achievement of proficiency in science learning. Moreover, Participant D expressed how students easily give up when they could not easily remember facts and formulae.

Lack of concept application. The teachers explained that the students failed to demonstrate the mastery of concepts and connection to what had been previously learned as expressed through the answers of at least three of the 12 participants. The transition from what had been previously learned to new concepts was always difficult. According to the teachers, students demonstrated this problem through the inability to explain concepts, present valid arguments and demonstrate application to the real world. Participant B stated:

> I find myself wasting time re-teaching concepts that I taught a day ago. Especially if the concepts build on to one another. They simply just don't remember and to prove this, I've given pop quizzes before teaching new content, and students are not successful.

The curriculum of eighth-grade science is made for the formal operational stage. Therefore, students find it difficult to understand how to apply science concepts despite easily remembering some concepts that are presented in a diagram or visual representation. Additionally, the teachers (Participants D and J) reported that students do not complete homework, and those who do complete it showed shallow understanding, direct transmission of memorized concepts or a wide similarity in the answers of different students. The lack of understanding of science concepts application among students may be linked to the lack of real world experience to connect to the lessons learned in science.

Lack of intellectual development. The theme indicating lack in intellectual development was also present in the answers of at least four out of the 12 participants. Participant G stated:

> Students are only learning for the moment, there is no transfer of knowledge. They simply don't retain, and they really don't know understand The Big Picture of what they learn, I try to make it meaningful, but they must learn to make that personal connection with what they learn.

Students lacking in intellectual development may experience difficulties in achieving high proficiency in science. To help students connect with their world, they must build upon their experiences and prior knowledge. However, Participant F and G expressed that most students already have poor performance in science in the past, which hinders them from exerting extra effort to become better at this subject. Teachers also claimed that the problems they were experiencing also experienced by teachers in other districts, as seen in the overall performance of students in standardized science tests. The lack of intellectual development is shown in the test scores of students in standardized science tests, wherein there is a decline in scores from 2012 to 2016.

Need for instructional strategies. The theme of the need for instructional strategies was common in the interview data (70% of participants) and in the documents reviewed. Participant C and Participant J claimed that if the teacher cannot come up with an engaging way of teaching, then most students will be bored and just decide to stop listening or trying to learn altogether. In the curriculum reviewed, there was a distinct lack in the instructional strategies prescribed to promote positive learning outcomes for students. The curriculum simply showed the topics and the expected output at each phase of the learning process for a specific semester. Furthermore, the district curriculum guide was the primary resource for the targeted schools. The assessment data revealed since 2013 the targeted schools have not been meeting science proficiency. Last, the Georgia department of education website recommended other websites to help students learn science. Specifically, the websites included an overwhelming amount of content paired with visuals; however, there were not many interactive games or tools that would engage students.

Summary. When I inquired about the challenges related to the teaching of science, the teachers unanimously agreed on one concept: the lack of motivation. The data revealed that under current instructional strategies, students were not motivated to learn, which has impacted their classroom engagement and the learning of critical skills. The teachers further reported that the lack of motivation was manifested in the lack of attentiveness in class and lack of clarity in answering questions regarding concepts that had just been taught. Furthermore, the students were not active in class, and even after knowing what would be discussed in the next lesson, they were not interested in doing further research, and as such did not have questions to ask. Additionally, the teachers indicated that they feel like they are merely passing on information to whomever is willing to listen.

Teachers who taught the students in the seventh grade also noted that the students who had been active in the previous year were engaging in unacceptable and disruptive behaviors in eighth grade. They also appear to have lost the energy they had in pursuing future science-related careers. The teachers connected these unacceptable behaviors and the loss of energy with decreased motivation.

The teachers further highlighted their uncertainty regarding the inclusion of the developmental and operational attributes in the current curriculum and educational strategies. According to participants C, D, and F, using the same instructional strategies, the students in previous classes (sixth and seventh grade) fully engaged in the classroom, were motivated and do their homework. Yet the teachers expressed being perplexed about what really happens when the same students transition into eighth grade. Moreover, the teachers reflected they had successfully taught the same students the previous year with the same instructional strategies. The students were energetic, completed homework, and though they did not ask many questions, at least by the end of the classroom session, one or two questions were posed.

The change of behavior was linked to the onset of adolescence. The teachers explained that adolescence often comes with rebellion, and many parents with children in adolescence can attest to the same. Participant I stated:

> Students are adjusting to hormonal changes, which can at times negatively affect their attitude toward learning; however, some students are mature and understand the importance of academic achievement and do their best. Ultimately, it is upon the students to realize their need to study for their future.

Additionally, four out of 12 participants agreed that teachers cannot use the same elementary strategies to motivate students to learn challenging content; it simply does not work. Another issue that arose with three of the participants was regarding students copying from one another. Participants B, F, and J expressed concern for these students, as they would be tested on the content and would eventually have to be accountable for their learning. They also supported their arguments by maintaining that the problems they were experiencing were also experienced by teachers in other districts. It was therefore clear that something is missing in the current curriculum and educational strategies.

One improvement that should be considered would be to always keep in mind during instruction the operational and developmental attributes of students. The lack of inclusion of operational and developmental teaching strategies is evident in the review of the current curriculum for science in the eighth grade. This insufficiency can result in changes in student behavior, which can lead to deteriorating performances when students transition to the eighth grade. The students seemed to have generally lost their sense of direction, and the teachers were desperate to establish how to improve the situation.

Lastly, having noted that the disconnection emanates from the lack of inclusion of developmental and operational levels in pedagogy, the participants recommended that development of a new set of strategies addressing higher developmental and operational attributes provide motivation toward critical thinking and learning of science. Although the teachers did not clearly state which strategies would be useful, four out of 12 participants highlighted that the new strategies need to help in increasing homework accuracy and completion, enhancing engagement in the classroom through taking over the learning experience, and motivating students to be more explorative, and stimulate curiosity and creativity to study further.

Discussion

The themes derived from research results are expanded in this section. These relevant themes address student behaviors, motivation, and attitudes, as well as teachers' instructional strategies and professional development. Unexpected findings are also discussed in this section.

Relevant themes.

Lack of motivation and negative student attitude or behavior impacts student achievement. Motivation is highlighted in the literature as playing a great role in student achievement (Ladd & Sorensen, 2017). Mega, Ronconi, and De Beni (2014) found high levels of intrinsic and low levels of extrinsic motivation generated the highest perceived performance, competence, and teacher acceptance. Also, student expectations and motivation were found to have a high correlation with self-confidence and expectations. Additionally, the expectations of students strongly predicted achievement (Mega et al., 2014).

In the situation where individuals have strong belief in their capability of accomplishing a specific goal, they have a higher likelihood of designing steps toward the achievement of the goal, and therefore, what follows is success (Komarraju & Nadler, 2013). Students' self-belief, which comes from their motivation to learn, is a strong factor in determining their academic attainment. Although intrinsic and extrinsic motivations are not differentiated, it is believed that the motivation addressed here is intrinsic, because it touches on self-confidence, which is an inner attribute.

Moreover, extrinsic motivation involves rewards and punishments (Cerasoli, Nicklin, & Ford, 2014), which has been discussed as leading to some sense of rebellion in the context of transitioning in developmental stages of the eighth-grade students. Concentrating on intrinsic motivation to learn does not mean operating in a lawless environment but applies to the placing of emphasis on the students' choices to learn and to perform the activities that contribute to learning based on their inspiration for something greater that requires time and personal sacrifice. The motivational problem can be addressed through better and more engaging pedagogical practices.

Curriculum lacks interactive strategies and students' lack of concept application. It is possible that the current teaching strategies have been addressing the learning needs of students appropriate for ages seven to 11 years while students' capabilities may have shifted to the abstract manipulation of concepts (Smith, 2016). Therefore, whenever incongruent strategies are presented, instead of learning the way the students used to, students get bored with the content and therefore miss out on the core subject matter, leading to lower standardized scores. Additionally, because students are not motivated in the classroom, the lack of motivation extends to their studies outside the classroom, leading to a general feeling of laziness in mastering previously taught content.

The failure to change instructional strategies with the students' developmental shifts is well documented in literature (Romero, Master, Paunesku, Dweck, & Gross, 2014). The transition of students into middle school is linked with greater rigidness in the rule structures and lesser support for the autonomy of students. Given that the sense of autonomy and decision-making is a developmental concern, reduced motivation may also be regarded as a way in which students express their rebellion to push for change (Furrer, Skinner, & Pitzer, 2014). Moreover, at this level, extrinsic motivational concerns often gain new significance, which may contribute to decreased academic engagement at the middle school level.

In the middle school, including eighth grade, children are at a phase wherein they need maximum or increased interaction with the world to gather experiences that they will use to process information and easily understand abstract concepts (Smith, 2016). However, participants claimed that the students in their classes cannot easily understand the concepts in relation to real-world applications, because of lack of experience in relation to the concepts being taught in science.

Need for teacher professional development and lack of student intellectual development. The results imply that the teachers are competent and well trained to handle their subject matter; however, their level of effectiveness and the students' capability to achieve more is dependent on the students' motivation to learn within the classroom and to research more and master content outside the classroom. The motivation changes at the eighth-grade level because of the variations in the development and the operational characteristics as explained in Piaget's (1936) developmental theory. Additionally, the level at which these changes take place may have occurred earlier than expected due to the rapid changes in technology, which has presented a shift in the ease of access to information.

From approximately age seven to 11 years, a child has the capability of using logic for the analysis of relationships and structuring of the child's environment into meaningful groups (Smith, 2016). Smith (2016) further explained it is vital for children to experience numerous interactions with tangible materials given their abstract thinking abilities are built on such understandings. During adolescence, individuals finally move into the period of formal operations and have the capability of abstractly manipulating concepts through hypotheses and propositions (Katsioloudis, 2015). If teachers lack professional development, especially during the transition phase of students to a period of formal operation, a lack of intellectual development may indeed be observed.

Unexpected findings. A general lack of motivation among the eighth-grade students was revealed in the data. The lack of motivation is evident with the answers of eight out of the 12 participants of the study. The lack of motivation resonates through the complaints presented by teachers, including quick transitions to teacher-centered classroom instruction because of lack of student engagement, inability to question evidence or present valid arguments, and unacceptable classroom and homework behaviors. Participants B and J expressed that if the students perceive the topic to be presented in an uninteresting manner, then they will not be motivated to learn. Moreover, Participants A, G, and H expressed that students perceived themselves to be poor performers when it comes to science in the past; hence they are simply not motivated to become better anymore. In the interview with Participant A, the researchers expressed the lack of motivation is from students' self-perception that they are not going to be successful with science from the very the beginning. The lack of student motivation emerges as the root cause of persistent student failure to meet required standards in science learning.

Research quality. I used triangulation and member checking to ensure quality. In triangulation, curriculum guides, GDOE guidelines and reports, tests and test scores were examined against the interview data as a way of checking for consistency. Secondly, it was expected that the number of interviewees would lead to data saturation, and as such, all possible views would be considered. The diverse opinions were checked for consistency, and clarification was sought on points of disagreement. Some of the discrepant issues encountered included an interview wherein the participant had only experienced teaching gifted students. Therefore, the responses to interview questions were in favor of gifted students being successful in science. The only challenge presented was the fact that sometimes the students challenged the teachers' thoughts and ideas, which made it difficult if teachers were unsure of the correct response to give the student.

Next, two of the participants requested their interview not to be recorded; however, they completed the interview in writing. The points of disagreement were not included in the main themes that emerged from the study, especially when there was not majority in either side of the opinions. Lastly, member checking was used for ensuring the perspectives of the respondents had been rightly captured. The participants were given copies of the draft results from which they confirmed that what had been recorded was their true perspectives.

Summary of the outcomes. The findings revealed that the perceptions of teachers regarding the ease of their students' learning and of teaching science were dependent on the abilities of the students. While teachers expressed that some students found science to be easy due to their ability to memorize surface content, teachers also expressed that some students found science to be difficult, because of the loss of interest and inability to remember facts and formulae. The teachers also revealed that students were unable to demonstrate mastery of concepts and connection with concepts that had been previously taught. Students were unable to explain concepts, present valid arguments, and demonstrate application to the real world.

Moreover, the teachers reported poor homework practices and low levels of engagement. These were linked to the loss of motivation among the eighth-grade students, as expressed in the interview data of eight out of the 12 participants. Given that these behaviors were not observed in the seventh or sixth grade, the teachers attributed the current behavior to the onset of adolescence and were uncertain regarding the inclusion of the operational and developmental attributes in the current teaching strategies and science curriculum. The teachers recognized a need for new pedagogical skills and strategies that would help in increasing homework accuracy and completion, enhancing engagement in the classroom through taking over the learning experience, and motivating students to be more explorative and study further.

The research was conducted under certain assumptions. The first assumption was that the school administration would be supportive through the entire process of research. The administration's support would be expressed through allowing participation in the activities that the entire research encompassed. The second assumption was that the respondents would be open and would display a disposition to trust to the extent of providing their honest opinion of the issues at hand. Lastly, research assumed that the school administration would honor the ethical agreement to confidentiality and would not force me to provide any information that would directly link the findings to any of the participants.

The major weakness of this study is that it does not capture the perspectives of students regarding their changed level of performance and motivation. However, this weakness does not affect the dependability of the results. Students may not be objective in narrating their challenges, and as such, their input may in a way distort the research findings. Students are also likely to express general disfavor for school, thus masking core issues sought after in the current research.

The other limitation is about the methodological inclination toward qualitative research. The lack limited the findings in the sense that it may be difficult to generalize the results due to the contextualization that comes with qualitative techniques. Therefore, difficulties may be realized in trying to generalize the findings in varied contexts from where the study was conducted. However, the transferability of the results was enhanced by discussing the findings in detail and providing a complete summary of the results from the analysis of the data. This transferability, combined with credibility, dependability and confirmability all build trustworthiness of qualitative research. Qualitative research is credible when it clearly summarizes the lived experiences of participants (Creswell, 2013). Describing the findings in detail allows the evaluation of the extent to which the conclusions drawn are transferable to other times, settings, situations, and people (Lincoln & Guba, 1985).

Dependability is when a study can be replicated a using the researcher's documentation (Creswell, 2013). I have tried to clearly document each step of both this study and the proposed project. Confirmability is when the researcher takes data and conclusions back to the participants for feedback on accuracy (Creswell, 2013). I achieved confirmability through member checks. All of these details and precautions helped build the trustworthiness of this study and strengthened the proposed project.

Project Deliverable

The outcome of the study will be the project deliverable, a three-day professional development training that will be conducted for the science teachers in the two schools (Appendix A). The professional development will be conducted in one of the two schools and will involve trainings, demonstrations and discussions every Monday for three weeks. The rest of the working days (Tuesday to Friday) will be dedicated to practice. Pedagogical strategies that are envisioned as solutions to the motivational problem will include authentic instruction, higher order questioning, argumentation and inquiry-based instruction. Teachers are expected to plan and practice the skills learned and to share their challenges with the other teachers. Sharing methods and strategies may be a way through which collaboration and support would be built for ensuring sustainability.

Transition and Summary

In this section, it was established that conducting interviews among 12 teachers of earth, life and physical sciences in the two selected schools in Georgia would assist me in identifying a core problem behind the consistent failure of eighth-grade students to achieve the mandated performance in standardized scores. The problem was identified to be the lack of motivation in the students, which emanates from the change in their developmental and operational attributes as outlined by Piaget. Furthermore, changes in instructional strategies were needed, particularly through adopting higher order pedagogical skills such as interactive homework, authentic instruction, argumentation, higher order questioning, and inquiry-based learning. The project will address all skills through professional development training.

In section three, the professional training project is discussed in more detail. The aim of the professional development and its specific objectives are discussed. This is followed by the discussion of the rationale behind the selection of the training as the way through which change can be realized. Moreover, different pedagogical strategies are discussed together with literature pertaining to the models of professional development, their quality and effectiveness. The implementation of the professional development and evaluation are further discussed.

The last section concerns reflections and conclusions. It begins with analysis of self as a scholar, practitioner, and even as a project developer. The project’s strengths and its potential impacts are also identified, including potential impacts in the local community and even further-reaching implications.

Section 3: The Project

Introduction

The need for achievement in science has been displayed among students who traditionally underperform (Han, Capraro, & Capraro, 2015). Research in Georgia has shown the same results, a consistent failure to reach the required grade levels in standardized tests. Based on the recommendations from the body of literature and the results from the interviews for this study, I developed a professional development (PD) training program with the aim of addressing pedagogical practices to create a longer lasting solution. In developing the PD with longer-lasting solutions in mind, I utilized information from numerous previous studies (Ertmer & Newby, 2013; Hsu, Wang, & Runco, 2013; Terrazas-Arellanes, Knox, Strycker, & Walden, 2016; van Aalderen-Smeets & Walma van der Molen, 2015). This section includes the objectives and details of the PD training. The rationale for conducting the PD is also provided, with comprehensive views of the possible outcomes normally associated with PD.

This section also includes a detailed review of literature. The review focuses on the motivational problem among eighth-grade science students in Georgia, strategies of enhancing motivation, and how these strategies can be delivered and reinforced by means of PD. The review leads to the discussion of the quality of PD as a factor that determines the effectiveness of the program. Moreover, this section also includes a discussion of modes of PD with the aim of presenting how these different models were incorporated into the multiple-model approach.

Following the literature review, the section includes the proposed project implementation. I focused further discussion on different phases of project implementation, resources and existing supports, potential barriers, timetable, and roles and responsibilities, which leads to the discussion of how the project should be evaluated. Lastly, I presented the implications of the project are presented, including the possible social changes within the local community and the potential of having far reaching implications.

Description and Goals

Due to the fast-changing world of teaching, teacher trainers often introduce numerous new teaching techniques. Keeping up with these changes in the teaching methodologies requires change in curriculum and in teacher education programs (Le Fevre, 2014). Given the indication that teachers lack sufficient skills to implement new and better instructional strategies, Hsu, Wang, and Runco (2013) indicated a need to train teachers (). This kind of learning is often referred to as PD and has the objective of enhancing the efficiency and competency of the teacher (Ertmer & Newby, 2013; Terrazas-Arellanes et al., 2016; van Aalderen-Smeets & Walma van der Molen, 2015).

PD is defined as any activity that is intended basically or partly for preparing remunerated members of staff for enhanced performance in their roles in the present or in the future (van Aalderen-Smeets & Walma van der Molen, 2015). PD is also defined as the activities that lead to the enhancement of career growth including continuing education, individual development, peer collaboration, peer coaching, peer mentoring, curriculum writing and in-service education (Terrazas-Arellanes et al., 2016). Moreover, PD can be regarded as the sum of both informal and formal experiences of learning from pre-service through retirement (Michaels & O'Connor, 2015). Considering all the definitions presented, PD is a way that teachers can gain knowledge that is intended to enhance their skills, and in the end, impact their classroom delivery. Teacher PD comes in many forms, including both top-down trainings and personal development activities initiated by teachers (Carpenter & Krutka, 2015). In the current project, training was chosen as the way through which instructional skill deficiencies would be addressed.

Four dimensions of PD exist, including development on the personal, school, management, and curriculum levels (Stoll, 2015). School development is a system- or a school-wide effort that is coordinated with the intention of introducing and maintaining change in the way in which schools are managed (Gamrat, Zimmerman, Dudek, & Peck, 2014; Stoll, 2015). Personal development refers to the development of political, social, and cultural skills by an individual who is focused on enhancing problem solving and communication in daily interactions (Bilgin & Balbag, 2016). Conversely, while management development places emphasis on the skills needed by persons in the management of schools (Richardson, Imig, & Flora, 2014; Stoll, 2015). Such skills would encompass effective delegation and leadership distribution (Richardson et al., 2014). School development most closely reflects the dimension targeted in the current project.

The traditional focus of PD has been on curriculum development with emphasis on the improvement of learning and teaching (Stewart, 2014). However, in general, the main objective of PD has been changing and enhancement of the current knowledge, notions, practices, and opinions toward the required standards (Le Fevre, 2014). In the current study, the PD will be aimed at enhancing the teachers' skills and capabilities to motivate students toward learning science and achievement through higher order instructional strategies like questioning, argumentation, authentic instruction, and interactive homework. By setting the aim, I am implying that upon completion of the PD program, one of the major success points expected would be increased student motivation and achievement in science.

In order to fulfill the aim, a number of objectives will guide the implementation and the assessment of the program. The first objective of the PD training will be to enable teachers to understand the link between motivation and instructional strategies that take into account the developmental and the operational level of the students. According to the interview findings, this lack of understanding appears to be the major problem affecting student achievement. Creating an understanding of the problem stimulates teachers in their quest for new knowledge and thereby driving learning (Park, Gunderson, Tsukayama, Levine, & Beilock, 2016).

The second objective is to develop a theoretical understanding of the new instructional strategies as the solution to the current deficiencies. The theoretical understanding is to enable the mastery of the philosophical foundation of these strategies, and how they stimulate student interest (Ertmer & Newby, 2013). Such an understanding will enable the teachers to set objectives based on the potential of the strategies to increase their motivation, engagement, and achievement (Ertmer & Newby, 2013).

The third objective is to develop the teachers’ confidence in the application of the new instructional strategies. The objective is based on the observation that teachers are less likely to apply new methods if they do not feel confident enough (Pancsofar & Petroff, 2013). The study emphasizes the necessity to design methods of building confidence to help teachers effectively implement strategies.

The fourth objective is to provide monitoring and support in order to achieve student improvement in standardized test scores. This objective involves the design of monitoring in a manner that will not interfere with teacher privacy and autonomy in the classroom, but which encourages collaboration. The establishment of support should not promote teacher dependency on me as the researcher but should enable the teachers to be fully established in their new ways of teaching and assessment.

Rationale

I chose PD as the means to address teachers' deficiencies for several reasons. In the first place, teachers' PD is needed for enhancing the quality their pedagogical practices and content knowledge (Whitworth & Chiu, 2015). Although teachers receive foundational knowledge through effective pre-service teacher training, PD can be employed for fostering the skill development of teachers and keeping them abreast with research (Wood, Goodnight, Bethune, Preston, & Cleaver, 2016). Therefore, the enhancement of quality may not mean that teachers are less qualified, but that through PD programs, they are able to remain informed and competitive in new and more effective instructional strategies. Wood et al. (2016) stated that PD has the capability of providing teachers with the additional skills and knowledge they can use in the application of research-based practices.

Moreover, PD can be employed as a policy solution for increasing the number of highly qualified teachers and to aid students in achieving high academic standards (Martin, Kragler, & Frazier, 2017). According to the National Research Council (NRC), teachers require pedagogical content knowledge that is specific to science, and this can only be achieved through PD (Miller, Curwen, White-Smith, & Calfee, 2015). Thus, PD has the potential of improving the quality of teaching, indicating that using PD in the enhancement of pedagogical practices in the current project is appropriate.

Secondly, PD enables teachers to reflect on the teaching practice (Escobar Urmeneta, 2013). Aside from engaging new knowledge, PD has the capability of stimulating teachers to think about their past practices and the associated problems. This leads to the determination of whether the new knowledge or skill gained could address the needs and the outcomes of students, and whether it is practical.

Lastly, PD has been linked to student outcomes (Desimone, Smith, & Phillips, 2013; Koellner & Jacobs, 2015; Lee, Longhurst, & Campbell, 2017). The link is especially important because, aside from training teachers in new pedagogical strategies, the current project targets the stimulation of students' motivation and engagement in learning science and ultimately improving their achievement. The relationship between PD and student attainment can be perceived as a stepwise progression that begins with the enhanced skills and knowledge of the teacher, enhanced classroom instruction, and finally an improvement in student outcomes (Cordingley et al., 2015). This relationship is mediated by the learning and the application of what is learned by the teacher (Desimone et al., 2013).

Several studies have been conducted with the objective of measuring the outcomes of PD programs. Shaha and Ellsworth (2013) found that schools whose teachers were actively engaged in PD that supported collaboration had higher levels of student achievement, and higher measures of educator and school success in areas like student discipline, teacher retention, and lower dropout rates, in comparison with the schools with lower levels of engagement.

Akiba and Liang (2016) found that PD activities in which teachers had informal communication and collaboration with each other reported greater effectiveness in the enhancement of student achievement. Similarly, Shaha and Ellsworth (2013) reported the achievement of student outcomes emanates from the way the PD program was delivered. Both studies supported PD activities involving communication and collaboration in order to be effective.

Gregory, Allen, Mikami, Hafen, and Pianta (2014) established that teachers who took part in PD experienced significant increases in the behavioral engagement in their classrooms, compared with teachers who did not participate. The authors further realized that the change in the level of engagement of students came from the employment of problem solving and analyses during instruction. These researchers also emphasized the importance of varied formats of instructional learning.

Gaikhorst, Beishuizen, Zijlstra, and Volman (2015) showed a significant impact of PD on the knowledge as well as on the self-efficacy of teachers. Gaikhorst et al.'s study is different from previous studies in that Gaikhorst et al. generalized the impact created by PD without the specification of the delivery techniques. However, it is not explicit about how the improved efficacy would enhance the student outcomes. Therefore PD has the capability to impact teacher and student outcomes. The outcome, however, is dependent on the objective of the training and consequently its techniques of delivery. One can also argue that regardless of the technique of delivery, when conducted with high standards, with accountability throughout, and with high stakes assessment and challenging curricula, the PD of teachers affects the achievement of students. Abdi (2014) noted teacher PD focused on pedagogical content and student learning has the potential of positively impacting the outcomes of students.

According to Wood et al. (2016), teaching strategies that are either research- or evidence-based are rarely practiced in the classroom, and this gap may be due to the absence of information about implementation, as well as the disbelief that such practices would result in improvement of student outcomes. Further, Wood et al. reported teachers revealed they felt no obligation to institute evidence-based practices and were not happy with the push toward using research-based practices within their classrooms. The teachers also reported a frustration with PD, indicating it did not match the needs of their students and did not provide them with enough support with the selection and the implementation of the practices. Not every PD is useful to teachers. However, if the PD is of high quality, then it will definitely impact student achievement.

Review of the Literature

Pedagogical Strategies

A comprehensive review of research established that intrinsic motivation among students can be increased significantly through pedagogical strategies that engage and support higher order thinking. Yeung (2015) explained that while lower order thinking requires mechanical or routine application of the learned information, higher order thinking challenges students about the analysis, interpretation, and manipulation of information for the purpose of problem solving. Moreover, the promotion of higher order learning and thinking requires the active engagement of students through dialogues and discussion, as well as argumentations (Pehmer, Gröschner, & Seidel, 2015).

[[The above was the last page I edited thoroughly, so please be sure to continue through this section and make the appropriate changes, as they are indicated above.]]

Teachers need significant professional support in the implementation of strategies that enhance higher order learning (Chee, Mehrotra, & Ong, 2015). Matherson and Windle (2017) posited that teachers are looking for PD opportunities that will provide a means of instructing their students through higher order techniques, which will in turn enable the students to engage their skills of higher order thinking across the curriculum. These strategies include higher order questioning, inquiry-based instruction, robotics, and interactive homework. In terms of support, homework practices appeared to be the most significant factor. The way homework is administered affects the relationships between students and their family, students and their classmates, and students and teachers.

Robotics. One example of pedagogical strategies is incorporating the use of robotics in instruction. Rihtaršič, Avsec, and Kocijancic (2016) defined robotics as a field that integrates elements from mechanical and electrical engineering, as well as computer science. Robotics brings in cognitive processes, including sensing, reasoning, and acting. Although robotics often has been employed as a powerful way to motivate students to learn (Rihtaršič et al., 2016), it is representative of the practical sessions in which students apply the concepts from the classroom to develop projects. Such projects not only force the students to apply classroom concepts, but also enable them to think of ways through which such applications can be useful in daily living. As students begin to appreciate that what they are taught is meaningful, their motivation tends to rise.

Inquiry-based instruction (IBI). Another pedagogical strategy is IBI. Psycharis (2016) defined inquiry-based learning as the deliberate process through which problems are diagnosed, experiments are planned, alternatives are differentiated, investigations are set up and conjectures are researched. Moreover, IBI includes information sharing, model construction, formation of coherent arguments, and the collection and analysis of data (Ku, Ho, Hau, & Lai, 2014). IBI is also defined as a multidimensional activity that involves observing, questioning and examining books and other materials, investigating and reviewing the experimental evidence, and communicating predictions (Abdi, 2014). Such instructional strategies include hands-on activities and student investigations, which help in the development of positive attitudes and enable the sustaining of student motivations.

Inquiry-based learning is different from other strategies in that it entails carrying out experiments and investigations within the classroom, inquiry by students through negotiation and problem solving, and the extension of student learning by the instructor beyond a level of set standards (Watt, Therrien, & Kaldenberg, 2013). Engagement in inquiry also involves the planning of investigations, the collection of data from different sources, the construction of explanations, the development of arguments from evidence, and the communication and defense of their conclusions (Lee & Buxton, 2013). All the practices mentioned enable the enhancement of conceptual comprehension of science.

As a contrast to the traditional pedagogy, inquiry-based learning is rather effective in the promotion of active learning. Students engage in the activities of learning, shifting the focus from the teacher to student-centered learning (Ji-Wei, Tseng, & Gwo-Je, 2015). Classroom discussions dominated by teacher instruction minimizes student interaction, hindering the social building of knowledge (Dole, Bloom & Kowalske, 2016). This shift from the teacher to the learner enables students to assimilate knowledge and engage in constructive arguments that, in the end, widens the student mindset through the promotion of critical thinking (Wu, Wu, Shih, & Wu, 2014). Teachers should therefore use a range of instructional techniques to challenge the meta-cognitive and the cognitive thinking of students to promote learning (Chiang, Yang, & Hwang, 2014).

According to Ozdem-Yilmaz and Cavas (2016), the engagement of students with the process of scientific inquiry motivates them toward physical and mental activity, enabling the development of competencies for effective future functioning in STEM courses. Moreover, the use of inquiry-based learning requires an extensive exploration of the necessary knowledge or information by the students in their process of problem solving (Ji-Wei et al., 2015). Therefore, the development and use of IBI and learning is a great way to increase students' levels of motivation and engagement, and in the end, acquisition of the required content knowledge and success.

According to Psycharis (2016), inquiry-based learning has been officially advocated as a pedagogy that leads to the improvement of STEM learning in numerous countries. Moreover, reforms in science education place importance on inquiry practices as the way through which students can develop their understanding (Lee & Buxton, 2013). Reforms in science education confirmed the effectiveness of the teaching strategy in the achievement of desired student outcomes.

Lee and Buxton (2013) explained that although there is strong advocacy for inquiry-based instruction and learning, most science teachers lack theoretical comprehension of the way science IBI provides support for scientific reasoning, communication, and problem solving. The implication is that even if teachers possess the pedagogical skill, they underestimate its impact on learning, and therefore, are not able to tap into its potential. Ulanoff, Quiocho, and Riedell (2015) further posited that there is a need to implement pedagogical practices that involve students in activities for the promotion of higher order thinking through inquiry-based learning. Implementing pedagogical practices provides the foundation through which the transfer of skills can take place. PD programs with a specific emphasis on explaining its importance can enhance student motivation.

Questioning. A third pedagogical strategy is questioning. In IBI, questioning is divided into higher order and lower order questions. Higher order questions require the mental manipulation of the information bits learned previously in order to develop an answer or to support answers with evidence that is logically reasoned (Şahin, 2015; Wang, Chai, & Hairon, 2017). Lower order questions, on the other hand, refer to the probing for exact recall (Şahin, 2015; Wang et al., 2017). In promoting higher order learning, teachers need training on the manner in which their questioning in the classroom can motivate students to go beyond recall to the demonstration of an understanding of the concepts (Rannikmae, 2016). Higher order learning will stimulate students to seek a better understanding of the concepts taught both from the teacher and from the materials available.

Argumentation. A fourth pedagogical strategy is argumentation. Argumentation is described as the process through which an argument is formalized. Students are encouraged to consider evidence in their presentation and defense of decisions in a manner that is logical and persuasive (Carson & Dawson, 2016). Through argumentation students find an opportunity to express their conceptual understanding of what has been learned and practiced (Asterhan & Babichenko, 2015). Argumentation gives students the motivation to learn more in order to confidently express themselves.

Evidence-based strategies like argumentation can be employed in the science classrooms for the development of the students' decision-making skills (Demirbag & Gunel, 2014). Moreover, students' conceptual comprehension can be enhanced through argumentation (Cetin, 2014). With argumentation, enhanced understanding takes place when students use scientific language and knowledge in an original way in their arguments (Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2013).

From the explanation provided, argumentation appears to be only beneficial for the students who have greater levels of expression and who are bright enough to learn concepts fast. However, Carson and Dawson (2016) explained that higher order processes like argumentation can be beneficial to students with lower abilities. Argumentation as an instructional skill is beneficial for both high and low ability students, especially when tactfully moderated.

Argumentation can be included naturally in the teaching of science in some way, although research shows that this may not be the case. Carson and Dawson (2016) revealed that in the science class examined, only two tasks involved group discussions and there was little guidance pertaining to how the group should handle the social dynamics related to the discussion. Carson and Dawson showed that teachers may not have argumentation knowledge, nor the pedagogical strategies related to it (McNeill & Knight, 2013). Chen, Lin, and Chen (2014), agreed, noting that the incorporation of arguments as vehicles for the learning of science is a challenge for teachers and students.

Authentic instruction. A fifth pedagogical strategy is authentic instruction Herrington, Reeves and Oliver (2014) defined authentic instruction as the combination of evaluation and instruction designed to enhance the achievement of students through lessons taught at elevated intellectual levels and which comprise skills and information whose value goes beyond school. Inauthentic techniques are, on the other hand, considered to comprise lower level skills, for instance memorization, regurgitation, or solving problems that have no real-life applications (Nie, Tan, Liau, Lau, & Chua, 2013). The shift to authentic instruction therefore involves a move toward higher order teaching and learning (Chee et al., 2015).

In many situations student learning has comprised the memorization of useless facts, the teaching of skills that students are not able to apply in their daily lives, or meaningless trivia without any value out of school (Ashford-Rowe, Herrington, & Brown, 2014). On the other hand, lessons taught in higher order involve requiring the students to conduct analysis, synthesis, and evaluation of information (Chee et al., 2015). Examples of teaching in higher order are requesting students to depict cause and effect in science experiments, come up with conclusions regarding what happened, predict different ways through which the problem can be solved, and argue for the best technique (Chee et al., 2015).

Interactive homework. A final pedagogical strategy is utilizing interactive homework. The reasons homework is assigned include the need to practice the skills taught in the classroom, preparing students for the next class, increasing their level of involvement, and contributing to personal development (Tas, Sungur-Vural, & Öztekin, 2014). Other reasons for giving homework may be to facilitate student-parent, parent-teacher, and student-student communication and as a way of fulfilling policy requirements for a certain level of homework (Tas et al., 2014). Homework is a normal part of the life in school and students in middle school have a higher likelihood of achieving better grades when they take extra time in completing their homework

(Letterman, 2013). This proposition is, however, based on several assumptions. In the first place, it is assumed the students have a positive attitude toward homework (Snead, 2016). Moreover, based on this positive attitude, it is assumed students use the homework as guidance for the development of the skills previously taught in class (Núñez et al., 2015). It is further assumed that the homework provided will stimulate students toward having a guided search for new information and presenting it as answers to the questions provided (Katz, Eilot, & Nevo, 2014).

These assumptions are, however, theoretical, and do not apply to many students. Most of the time, homework is perceived as excessive and does not leave the students with any time for themselves or to engage with family (Letterman, 2013). In many cases, homework is not completed, and when done, students appear to have been in a rush and failed to master the content, leading to high levels of inaccuracy (Katz et al., 2014). Moreover, where accuracy is high, there is often a tendency to copy one another's homework, especially when what is required appears to be a fact, or a set of calculations (Aremu, Gbadeyan, Sofoluwe, & Aremu, 2015).

One way of solving the problems of homework is to shift toward interactive homework (Aremu et al., 2015). Interactive homework such as Teachers Involve Parents in Schoolwork (TIPS) enables the students to interact with their family partners concerning the skills they have learned in their classroom and to apply the concepts in the real world (Ariës & Cabus, 2015). Interactive assignments are designed in a manner that parents with no education can still provide answers to the questions asked, with the focus being on what the students are intended to learn and not on the knowledge of the parent. Tas et al. (2014) posited that the involvement of parents in homework has positive effects on student outcomes, for instance, their attitudes concerning homework, and their perceptions of self-competence.

The use of interactive homework stems from the producers' way of promoting hands-on experience and discovery in a manner that makes the study of science to be of relevance and interest (Gonida & Cortina, 2014). Moreover, while independent assignments often have to be completed by the next day, the interactive assignments allow for a few days or a week, thus respecting family time (Ariës & Cabus, 2015). The research conducted by Aremu et al. (2015) revealed that eighth-grade students using TIPS assignments had increased levels of family engagement in their assignments, completed more of assignments, had higher accuracy rates, and had higher report card grades in science.

Teachers need to go beyond just assigning homework to designing homework (Ariës & Cabus, 2015). Designing homework requires the teachers to take into consideration the objectives, format and other factors that will increase student engagement and enable them to succeed (Gu & Kristoffersson, 2015). However, there have been no structures that can help with the procedures for homework, and teacher education programs do not provide sufficient information on homework (Kazantzis, Dattilio, Cummins, & Clayton, 2013). Furthermore, lesser attention has been given to homework design that encourages interactions within the family (Ariës & Cabus, 2015). The implication is that there is a need to support teachers in the design of homework that will achieve its intended purpose, which can be done through PD.

Quality Professional Development for Pedagogical Change

The literature indicated the solution to the motivational problem among eighth-grade students is through a change of pedagogical strategies employed in delivering content and reinforcing learning. According to Lee and Buxton (2013), teachers need first to have the conceptual understanding of what they need to teach before they can implement the practices that are reform oriented for the enhancement of scientific inquiry and understanding. Teachers were found to possess excellent knowledge and the required competencies, but lacked the skills to deliver content in a manner that motivates students to learn beyond the classroom. Research further indicates that PD is necessary for the delivery of change (Lee & Buxton, 2013).

However, not all PD programs are of adequate quality. The higher order strategies proposed, including inquiry-based learning, questioning, argumentation, authentic instruction, and interactive homework, can only be successfully delivered through quality and effective PD programs (Williford et al., 2017). The need for quality and effectiveness is further echoed through the National Staff Development Council (NSDC). The NSDC posited that PD ought not to be regarded as a one-shot chance for disseminating information on classroom reform practices and innovation, but must be job embedded, results driven, and standards based (DeMonte, 2013). Any PD program must be designed with purposeful quality and effectiveness to deliver change and ultimately increase student achievement.

Quality and *effectiveness* are different terms but are interrelated. While *quality* is relative and particularly based on meeting certain preset standards (DeMonte, 2013; Sumsion et al., 2015), *effectiveness* is the ability of the program to deliver the much-needed change (Bayar, 2014). Although high quality PD programs are of importance in the improvement of schools and in accomplishing the objectives of No Child Left Behind

(NCLB) as well as state mandates throughout the country, not many programs have met the required standards for quality (DeMonte, 2013). Furthermore, PD programs often have not been purposefully planned and their implementation has been haphazard. Therefore, the majority of school improvement and PD activities have not impacted the knowledge and skills of teachers and, as such, have demonstrated ineffectiveness (Cordingley et al., 2015).

The design of quality PD programs can be aided by the PD standards developed by the NSDC in partnership with key state organizations (Green & Allen, 2015). These standards offered a framework that enables the entire PD to have a high level of effectiveness with the teachers, school leaders, students, and with greater focus on the achievement of students (Shaffer & Thomas-Brown, 2015). NCLB also gave the attributes of a high-quality PD (Bayar, 2014). These included sustainability, intensiveness, and content focus; the alignment of the PD with the academic assessments and standards; the ability to result in the improvement of the content knowledge of teachers; the enhancement of evidence-based instructional techniques; and the assessment of teacher and student effects (Wood et al., 2016).

Aside from the standards set by the NSDC and NCLB, high quality PD programs have been considered among professionals as including long duration, active engagement, follow-up support, and shared comprehension of student attainment (Williford et al., 2017). Additionally, the elements that make up a high-quality PD program include the context that is characterized by leadership, learning communities, and resources. PD is a process which includes collaboration, is research based, driven by data and entails evaluation. Finally, quality PD has content involving family and encouraging equity and quality learning.

Quality is defined by certain aspects such as whether it is connected to the classroom, whether it reflects the vision and mission of the school or district, and whether it attends to certain interconnected systems. A high-quality PD envelops practice, demonstration and coaching, results in the increase of the skills, knowledge, and application by the teachers. PD without these qualities leads to ineffectual and fragmented attempts toward correcting surface issues (Wood et al., 2016). In order for PD programs to have an impact, they have to be analytical in nature and reflective of the mission of the program, as well as the vision and the mission of the school. Steeg and Lambson (2015) regarded the features of an effective PD program as the ability to place emphasis on the subject matter; active learning by the teachers; the consistency of the program with the school's beliefs, knowledge, policies, and reforms; and the PD's duration and collective involvement of the teachers.

Hilton, Hilton, Dole, and Goos (2016) posited that the effectiveness of learning is achieved in a PD program when it has a relationship with the context and the expectations that teachers have. PD should include opportunities for the teachers to identify their individual needs in learning and reflect on their practices. At the same time, PD should focus on the learning needs of students and the way such needs ought to be addressed. Furthermore, PD should be continuous, supportive, and lead to the immersion of teachers in learning activities that can be employed in the classroom. Furthermore, PD is effective when focused on the implementation of the curriculum and when it explicitly links curriculum imperatives and learning activities, drawing from numerous information sources (Hilton et al., 2016).

Effectiveness of PD can also be measured by the level of successful utilization in the classroom setting of the strategies learned. According to Matherson and Windle (2017), teachers are seeking the kind of PD that they can use immediately to aid in preparation, delivery methods, skills, and strategies which permit them to address individual student needs and customize differentiated instruction. PD programs are more successful when they are more connected to classroom lessons.

PD success has also been monitored in terms of its inter-relatedness with school systems. The system's view of PD was presented by R. Miller et al. (2015). The authors explained that the success of PD programs is based on their ability to attend to three systems that are mutually informing and interrelated. These systems include the learning activity which entails the coherence of PD activities, the time provided with supervision, and opportunities for teachers to reflect.

Finally, effective PD includes the teachers' beliefs, perceptions and values, as well as the school's or district's context including the school routines, policies and practices (R. Miller et al., 2015). An effective PD model is inclusive of three pillars, which are PD, classroom support, and curriculum resources. The links among these pillars enable a sustainable change in teacher practice while enhancing student learning.

Models of professional development. Quality PD is measured in accordance with the standards set. However, it is possible that a PD program that meets the defined quality criteria fails to be effective as it pertains to the fulfillment of its objectives. Failure would be attributed to the approaches used in the delivery of the programs.

Derri, Vasiliadou, and Kioumourtzoglou (2015) explained that when the PD of teachers is influenced by approaches that are research based and are social-constructivist in nature, it is considered as part of the lifelong learning of teachers. Moreover, PD becomes reflective of the process of skills, competencies, attitudes and knowledge acquisition throughout teachers' careers for the enhancement of their effectiveness and the promotion of student learning (Derri et al., 2015). Therefore, Derri et al. promoted social-constructivist strategies encouraged effective and sustained change in teacher PD.

The support for social-constructivist models stem from the emphasis that PD is most useful when it places emphasis on active teaching, observation, evaluation, and reflection (Matherson & Windle, 2017). When the PD sessions are designed with these considerations in mind, teachers may develop pedagogical skills, which are needed for the enhancing student learning. Additionally, teachers who take part in professional learning communities have been found to engage in continued collaboration and dialogue for the enhancement of teaching and learning (Burke, 2013). Various models of PD include teacher-centered PD, reflective PD, experiential PD, and problem-based learning.

Teacher-centered professional development. PD that focuses on the teachers will utilize the social-constructivist method. Specifically, teachers gather to discuss their teaching circumstances and the manner in which they can handle such situations. Collaboration enables not only the acquisition of knowledge by the teachers, but also the implementation of the knowledge acquired in the classrooms.

As opposed to a focus on abstract discussions, PD that is most useful usually involves the active participation of teachers together with hands-on experience. All of this can only occur when there is social interaction among the teachers, rather than having teachers merely sit and listen to a speaker. The major objective of the teacher-centered PD is to enable teachers to own the process of PD and to promote a genuine interest and effort in the development of their competence in teaching.

Reflective professional development. While some educational institutions place emphasis on the skills of classroom delivery, citing that particular elements of a program are at the core of the development of their faculty, other models use the reflective teaching technique. According to M. Sarma (2015) reflection is broadly accepted in the education field as a technique of learning and is regarded as necessary to professional practice. Reflection enables experiences to be more meaningful, promoting deeper learning because of its ability to encourage the framing of problems, questioning of assumptions, and examining situations from numerous perspectives as individuals analyze their lived experiences.

Reflection is recommended by the National Staff Development Council (NSDC) as a follow up activity that is effective in PD (Ho & Arthur-Kelly, 2013). Teachers are more active when PD entails discussion, sharing, and reflection (Ho & Arthur-Kelly, 2013). PD, therefore, needs to have collaborative activities, which give opportunities for reflection, sharing of expertise, co-construction of knowledge and the revisiting of beliefs concerning teaching, as well as learning. The practice is both valuable and persuasive for making sure that the experience of teachers and their expertise are built in real contexts. However, reflective teaching is not PD, per se, but has an impact on PD.

Experiential professional development. According to Blair (2016), experiential learning is many times defined as a technique for active engagement of students in the processes of learning. Just like with students, learning by teachers takes place when they do the activity, read, and reflect; through collaboration with other teachers; take a close examination of students and what they do; and share their observations with other teachers (Burke, 2013). Learning starts with the experiences that lead to stimulation and that form the basis for learning. Through the internalization of such experiences, the learners get to think, reflect, and act (Blair, 2016).

Experiential learning places emphasis on pedagogical approaches that are grounded social constructivist and cognitive learning theory (Blair, 2016). Experiential learning happens through the activities conducted by teachers, which enable them to converse with one another concerning possible challenges. Experiential PD is a learner-centered approach (Valdmann, Holbrook, & Rannikmae, 2017).

In experiential learning, participation of the learner is at the core when content identification and comprehension come through their experiences (Blair, 2016). In PD, the teacher is the learner. Burke (2013) maintained that PD needs to encourage the maintenance of the roles of both student and teacher and permit them to struggle with the uncertainties that come with each of those roles to deepen their pedagogical understanding. The struggle leads to the development of an understanding of what students undergo in normal classroom contexts. The result is the creation of some sense of empathy, which ultimately promotes the search for better pedagogical strategies that promote motivation and engagement.

These experiences take numerous forms, like project-based learning, place-based education, as well as service learning. The experiences also take the form of demonstrations where the teachers alternate in assuming the roles of teachers and students in the context of experimentation with the teaching strategies learned. PD appears to work best in situations aligned with teachers' day-to-day activities (Hemphill, 2015). Teachers need to be engaged with materials in classroom settings, which give them the empowerment to experiment the new strategies. The activities provide opportunities for the teachers to reflect on new strategies and activities for student learning (Hemphill, 2015).

Problem-based learning (PBL). PBL is described as the utilization of authentic and ill-structured problems requiring the learners to come up with specific concepts as they build solutions to the problems (McConnell, Parker, & Eberhardt, 2013). PBL also requires the participants to assess their known information, identify the learning problems and hypotheses, and conduct research by means of experimentation to gaining a deeper comprehension of the ideas connected to the problem. PBL also required participants to discuss how these ideas apply to the problem. Problem solving in PD results in synthesis of concepts, thus enabling the teachers to learn beyond ideas that are isolated (McConnell et al., 2013).

As a PD strategy, problem-based learning has several advantages. First PD passes the responsibility of learning, although facilitated, to the participants (McConnell et al., 2013). With questions from the participants guiding problem solving, PBL adjusts in accordance with the students' needs and their levels of understanding. PBL is an inquiry approach that is widely applicable and easily internalized (McConnell et al., 2013).

Implementation

The design of the PD project for this research study incorporates the numerous findings from the body of literature and is based on the problem that students have not consistently met the standards of science achievement mandated by the state because of their lack of motivation in science. Moreover, the program design considers factors recommended for enhancing student motivation toward science learning. These factors include the design and implementation of interactive homework practices and the adoption of higher order learning practices in the teaching of science, such as inquiry-based classroom instruction, authentic instruction, questioning, and argumentation.

Hilton et al. (2016) posited that teachers use their skills for two major objectives: conceptual understanding and skill efficiency. However, the motivation of students to learn, which emanates from the instructional methods used, determines whether the students will grasp the concepts and whether they will make any extra effort in the mastery of the concepts. Consequently, the design of the PD was centered on instructional strategies that not only enable conceptual understanding and skill efficiency, but also motivate students toward science learning and mastery of content.

The PD program was designed in a series of stages that reflect the activities to be undertaken. The development of the stages and the activities was supported by existing literature. Additionally, various models were incorporated in the design, ensuring the achievement of a multi-model, quality, and effective PD program.

According to Ho and Arthur-Kelly (2013), traditional approaches place emphasis on direct transmission of information, were short term in nature, and relatively lacked effectiveness. Observation led to the consideration of a different style of design for PD training. The design of the program incorporated the five components proposed by Ho and Arthur-Kelly (2013), which enable the effectiveness of the PD program, including theory, demonstration, practice, feedback and coaching. These components were woven throughout the program design.

Design of the Professional Development Program

Stage 1: The selection of participants. The PD program will involve eighth-grade teachers of earth, physical, and life sciences from two schools in Georgia. These teachers will be grouped into three clusters in accordance with the science subject taught. Clustering will aid in discussions, enhancing some sense of collaboration.

The activities are designed for the interschool clusters for supporting, encouraging, and starting the process of building a community of learners. Ho and Arthur-Kelly (2013) reported that teachers who frequently engaged in collaboration and cooperative learning together with their peers felt confident and well-prepared for working in the modern classroom. These findings emphasized the importance of encouraging a supportive learning community where teachers can share their perspectives and provide solutions to problems.

Moreover, the program was designed to allow the collaborative efforts in the clusters to evolve into professional learning communities following the PD. Ho and Arthur-Kelly (2013) described a professional learning community as an environment that fosters mutual cooperation, personal growth, emotional support, and synergy of effort. As such, these communities will continue to be useful in the future.

Aside from the choice of the teachers to enable collaborative engagements, the experience is also a factor in the design of the PD program. According to Chikasanda, Otrel-Cass, Williams, and Jones (2013), PD for experienced teachers should be rich in theories of student participation in learning. Experienced teachers exhibit commitment, professional experience, and maturity (Chikasanda et al., 2013). For these reasons, participants for this project will be chosen only if they are teachers of earth, physical, and life sciences with more than five years' experience of teaching eighth-grade students. The selection of the participants will be done prior to the training.

Stage 2: The presentation of the problem. Following the selection of participants, the next stage will involve discovering their approaches and beliefs of student motivation, engagement, and achievement in science. The presentation of the problem step is important because, unless they can identify that the problem lies within their current instructional methods, they will not be open to learning. Moreover, some teachers would have already used some of the strategies included in the PD program in their teaching, helping them understand better ways of delivering the same strategies with possible outcomes that can create the impact that they have longed for.

In this stage, some level of expectation will be created through a quick preview of how the entire program will run. A preview will be done to allow them to come up with questions in advance and to reflect on their past teaching strategies and the impacts the strategies have created so far. My reflection will be regarded as useful in the later days of the delivery when individual strategies will be addressed. Lastly, the teachers will be asked to write their expectations of the program. Reviewing teachers' expectations of program will help in discovering deeper needs that may not have been captured in the design of the PD program and in capturing the potential barriers to learning and implementation. A one-hour period is allocated each day for the presentation of the problem related to the pedagogical strategy that will be taught on that training day.

Stage 3: The presentation of the theory. Theory will be used in explaining and justifying the new approaches. In the demonstration, a model will be constructed in the way this theory can be put into practice. Accounting for the interconnected nature of the professional growth of teachers, a series of PD workshops will be designed, which brings together both theory and activities that are classroom based with the objective of enhancing change in both the knowledge of teachers and their classroom practices.

The workshops will be student (participant) centered with each of the sessions, including content specific presentations which address theory. However, the students of the workshops will be the teachers of science. For clarity the term participant will be used to indicate teachers in the role of students in these workshops. The presentations and demonstrations will all be detailed in PowerPoint presentations. Nevertheless, most of the time will be spent on enabling the immersion of participants in learning activities, which could be adapted and used by their students. Time will also be allocated for the sharing of participants' reflections on their work in the workshops combined with discussions of teaching approaches and activities led by participants. This will help in reinforcing the aspect of the demonstration.

PBL is the common strategy in the different content strands and will be employed in strengthening the ability of participants to engage in instructional strategies that can motivate learners. These activities are designed to engage participants in identifying the potential barriers to the implementation of the strategies learned and to get participants to solve the problems in a collaborative manner. PBL will be used as a way of increasing implementation of the strategies. Participants will give their insights as to which instructional strategies work best for their classes.

With the workshop activities conducted in a manner promoting collaboration, participants must support each other when preparing for presentations and in the development of new concepts. Research shows that sustainable change is realized in interventions whereby teachers' roles are legitimated, acknowledged and rewarded (Chikasanda et al., 2013). Therefore, it was envisioned that the development of strong learning communities stemming from the collaboration of participants in PD programs would result in instructional enhancement and teacher learning (Chikasanda et al., 2013).

With the focus of the study being enhancement of student achievement in science, a design-based approach to research will also be adopted in practice. This approach entails developing practical solutions in an iterative manner, resulting in usable research insights and products through a closer interaction between the participants and the researcher (Hilton et al., 2016). This approach is advantageous, being able to respond to the circumstantial attributes, accounting for the complexity of the naturalistic classroom environment (Hilton et al., 2016). This approach will also acknowledge that learning by teachers is recursive, involving sequences of the cycles of designing, enacting and evaluating. It will also promote the collaboration of teachers with the objective of the promotion of practice and knowledge, as well as salient outcomes.

Stage 4: Classroom-based practice. Practice is where the new knowledge is applied. The participants will be asked to apply the content of what was discussed in their classrooms. The outcomes of these activities will be reported in the next workshops.

According to Ho and Arthur-Kelly (2013), teachers hold the belief that PD is of relevance when the activities within the program are related to their day to day responsibilities. Therefore, the use of classroom-based practice enables the teachers to engage in the new methods and identify potential challenges encountered in delivering content, using the strategies learned. Moreover, motivation is improved when the PD training tackles participants' needs and enables them to gain professional knowledge. As such, it was envisioned that teachers would have greater motivation when they come to the realization that these strategies work.

According to research, the effectiveness of teaching practices may emanate from fundamental changes in pedagogy. However, the change is also likely to be influenced by the teachers' theories and the beliefs regarding teaching and learning, as well as how willing teachers are to welcome change (Chikasanda et al., 2013). According to Hemphill (2015), the changes required in the beliefs and the attitudes of teachers may take place only following an experience with successful implementation that proves to positively impact the students.

The practice sessions in the PD program will be expected to influence teachers' beliefs. Furthermore, these changes in beliefs, leading to changes in pedagogical strategies, are expected to influence students' engagement and motivation. Therefore, a PD program that uses classroom demonstrations is regarded as useful. Participants will attempt to implement what they learn, keeping in touch with the other teachers within their PD clusters to discuss the challenges encountered and to devise solutions to ensure effectiveness.

Stage 5: Reflection and support. Between the workshops, the teachers and I will maintain close contact. I will provide materials and support online, with occasional school visits to provide the support required. The interaction aims to achieve the fifth target, which is coaching. At the end of all the workshops, the teachers will be requested to adapt the activities learned in the workshop to meet the needs of their students or design their own activities and try them in their classrooms.

To insure carry-over and application of PD material, participants will be required to write PD plans in preparing classroom activities. According to Janssen, Kreijns, Bastiaens, Stijnen, and Vermeulen (2013), PD plans help participants in structuring their

PD into learning objectives and plans of action. PD plans also enable teachers to reflect on their performance, to plan their learning, and to showcase their competencies. When the teacher learning is authentic, success is based on developing, implementing, and supporting activities, learning, and school systems. Therefore, the development of the PD plans enables participants to process the authenticity of the PD training.

Reflection and support will also be provided through ongoing teacher meetings and observations. The continued support will enable learning and promote sustaining change in the adoption of the new teaching strategies. Following the presentation of the problem at hand and how it was impacting students' scores, the participants are expected to willingly acknowledge that change to their teaching will be necessary. Moreover, after the preview of what it would take to change the situation, the teachers are expected to be willing to go through the PD program.

Potential Resources and Existing Supports

In the implementation of the PD program, the major resources are willing teachers and supportive leadership in the schools. The teachers need a desire to improve the classroom situation and to be willing to share their ideas and problems with each other. The interviews in my original study were conducted among the teachers, confirming they needed to improve their knowledge of various instructional strategies that promote student motivation toward science learning. The combination of the interviewees' insights and Piaget's developmental theory was used in the development of the workshop materials, enabling teachers both to identify the motivational needs of their students and to place emphasis on practices that have the probability of addressing these needs in the classroom.

Burke (2013) maintained the belief that the instigation of meaningful change requires teachers to enhance their practice and take part in the determination of what they will learn. In the context of the PD project, the teachers will take part through reporting their classroom challenges and in desiring to learn the practical ways through which those challenges could be addressed. Also, teachers who exhibit success can share what different activities they have done and how the strategies they used can be adopted by the other teachers in their respective contexts.

Secondly, the teachers' willingness to share information will ease the process of establishing collaborative relationships among them. As collaboration was considered in the literature to be of great importance in the promotion of teacher learning and in the formation of professional learning communities, it became an integral part of the proposed program.

The extent of participation and the degree of the authority of decision making in PD reflects the general structure of management of the school. Even with good PD content, the absence of support from organizational process and strong decision making would make the results short lived. In Turkey Bellibaş (2015) revealed found the effectiveness of instructional leadership is determined by its relationship with the teacher's privacy in the classroom, the leader's content knowledge, and leadership practices' coherence.

Aside from permitting the teachers to take part in the PD program, school leadership can demonstrate support through their presence in the workshops as observers. Teachers from other disciplines also may attend the workshops, presenting involvement of interdisciplinary subject groups in the implementation of PD, which with a wider leadership base would enable the sustenance of the changes brought about by the PD.

Potential Barriers

Even with both teacher and administrative support in the PD, all programs face potential challenges. While some challenges can be addressed, some involve contextual issues and require system-wide changes. These challenges have an effect on predicting impact and sustainability of the program.

Foretelling the impact of the pedagogical strategies. Although research agreed on the elements that make up an effective PD program, these elements are not able to foretell the impacts of the programs (Hemphill, 2015). I will share this sentiment in the design and the delivery of the PD program. The formation of the strategies that would lead to change will be purely theory based. Teachers may find it difficult to assure that they can work beyond theory. Moreover, the teachers will require a lot of patience for the learning and practicing process as the places in which they had been applied have different contexts. If the teachers encounter problems, I will rely on their clusters and previous experience to help with the solving of those problems, thereby shifting the program from myself to the teacher-participants.

Barriers to sustainability and scalability. There are two very key attributes of successful impact of PD: sustainability and scalability. While sustainability refers to the time-to-time and longer lasting renewal, scalability means the capability of reaching all persons and broadcasting ideas (Tondeur, Forkosh-Baruch, Prestridge, Albion, & Edirisinghe, 2016). The question after the PD will be whether the teachers will continue with the strategies learned. The uncertainty comes with the work involved in the engagement of these practices. Also, the use of argumentation and higher order questioning is required for teachers to have a deeper understanding of the context and subject matter to more effectively answer the questions posed by the students.

The limitations related to the scalability of PD include cultural and social factors, and geographical separation. Given that the PD program will emphasize contextual issues and find solutions for such problems, it is not known whether the same strategies can be applied in different contexts. More specifically, the success or failure of the program will be based on the willingness of the teachers and the administration to adopt and execute changes in their instructional strategies. These barriers can however be reduced or eliminated through social networking, the development of professional communities and the use of the Internet as a means of facilitating communication. The teachers themselves can use the Internet and social networks for sharing, and if these resources are tapped, they allow sharing of issues and solutions and ultimately, the proliferation of the instructional strategies learned.

Contextual factors as barriers. Hemphill (2015) explained that the reason for PD ineffectiveness is the failure of models to consider the manner in which professional learning becomes embedded in the working contexts of teachers, or the manner in which their individual experiences, values, and preferences impact the results of the PD. Supporting the impact of the contextual factors on the implementation and the sustainability of the strategies taught and learned, the participants in Casey, Starrett, and Dunlap (2013) expressed their fears over organizational factors. Additionally, Hemphill posited that the findings from the PD research often cannot be applied in other contexts and may be conflicting.

One such factor is the openness to collaborate with other teachers. In Forte and

Flores (2014), teachers cited possible challenges to collaboration as being at the organizational level, such as working conditions and time. According to Fitzgerald and Theilheimer (2013) development of a climate that fosters trust, openness, and respect is needed for teachers to take the risk and initiative to learn together. The school's climate is dependent on school leadership that displays the willingness to innovate, accept challenges, and permit the autonomy of teachers. Districts, and even schools with in districts may vary, impacting the ability to generalize the findings of the current project to different environments.

Another contextual factor affecting scalability is the variation of the working conditions in various institutions. Over the years, the work of teachers has grown to become more intensified, leading them toward isolation and in some cases, teachers are overstretched and demoralized (Broad, 2015). Broad (2015) reported that teachers find it hard to cope with constant changes and to balance their learners' needs with funding sources, inspectors, and managers' demands. As such, instructional strategies may be hard to implement in school environments where teachers are overworked and unwilling to exert the extra effort required for change.

Further, in schools and districts where the teachers are required to attend PD as a performative measure, proliferation of strategies may be difficult. Broad (2015) defined *performativity* as a form of regulation that uses comparisons and judgments as ways of measuring output or productivity. The assessment criteria imply that measurable outputs as well as targets turn into the justification for taking action, and the force that drives teachers to focus on their targets, outputs, and performances. Teachers within performative environments do not exhibit the intrinsic motivation required for the success of learning the instructional strategies presented in the PD.

The expectation of quick changes. Sustainable change requires the exertion of effort, but in a steady and evolving manner (Tondeur et al., 2016). Brown and Inglis (2013) recognized that change following PD is not instant, but a slow process and only takes place when the change is intensive and sustained and where it is implemented in a gradual and incremental manner. At the start of the PD, participants may expect some changes to be immediate and some to take time. They will be informed that the changes they desire, the improvement in standardized scores, will require consistency in the use of the instructional techniques learned and constant collaboration with other teachers as a way of maintaining support and addressing emerging issues.

Proposal for Implementation and Timetable

PD programs often have been regarded as ineffective when in-service workshops have been conducted in a traditional manner (Hemphill, 2015). Many times, PD is conducted within a day, leading to little enhancement in the performance of the teachers (Wood et al., 2016). Additionally, teachers have few opportunities for practicing the newly-learned skills and often do not get any feedback on their performance (Wood et al., 2016). The design of the PD for this project considers these fundamental issues. Rather than the traditional methods where participants have a one-day workshop, this PD encompasses a series of workshops that incorporate various ways of learning that are experiential, problem based, and participant centered, and which require the participants to collaborate within their clusters. Moreover, periodic reporting of challenges and the desired solutions mean that the activities will be conducted in a cyclical manner.

A cyclical design means that the presentation of theory, problem-based discussions, practice, and reporting are done for each of the pedagogical strategies. The sequence helps in making sure that teachers gain competence in one strategy before moving to the next. Additionally, the pattern contributes to the effectiveness of the entire program. However, this kind of design is slow, and therefore requires a lot of time. Through collaboration, with the leadership of the various schools in this study, a possible schedule was discussed that teachers could possibly avail themselves every Monday and assume their daily duties on the other days of the week. Ultimately the teachers should be required to be available for trainings for three days. The details of the activities conducted throughout the day for the three weeks are presented in Tables 1, 2, and 3.

Roles and Responsibilities of Stakeholders

PD involves a variety of stakeholders, ranging from administration to teachers to students. In addition to the teachers who qualified to participate in this project study, others involved in the PD may include the school leadership, teachers of life, earth, and physical sciences who did not meet the criteria for involvement in this study, as well as teachers of other disciplines. The proposed PD has been tailored to teachers. Teachers need to be responsible for their PD. Competency in PD means that a teacher is responsible for the identification of personal and institutional needs and the effort to meet those needs. The program design places on the teacher the responsibility for changes in the motivation, engagement and finally achievement of the students.

Hypothetically when instructional methods change, the change would be transmitted to the students’ level of achievement through the change in their intrinsic motivation. The intrinsic nature of the motivation would then drive them toward feelings of self-efficacy, the desire to achieve more, and ultimately working toward improved

Table 1

Day 1 (of 3) activities for the training

Day	Time	Activity	Details about the activities	Materials
Day 1	08.30 am - 09.00 am	Introduction	Teachers know each other and the clusters where they belong.	No specific materials needed
	09.00 am- 10.00 am	Introduction	Outline of the expectations of the entire training	Power point presentations
	10.00 am – 10.30 am	Break		
	10.30 am – 01.00 pm	Authentic instruction	Teachers are presented with the problem. Teachers are taught the skill of authentic instruction, including demonstration of concepts.	Power point presentations
	01.00 pm – 02.00 pm	Lunch break	Teachers can break for lunch within their clusters, asked to reflect on what was learned.	
	02.00 pm – 03.00 pm	Questioning	A discussion period involving questioning and answering from both the instructor and the teachers	
	03.00 pm – 04.30 pm	Problem solving	Teachers go into their clusters, solve the problems provided by the researcher.	The problem to be solved projected

Table 2

Day 2 (of 3) activities for the training

Day	Time	Activity	Details about the activities	Materials
Day 2	08.30 am - 10.00 am	Evaluation (Authentic instruction)	Teachers report on how they practice the authentic instruction skill, discuss challenges, support, immediate outcomes, and seek support.	
	10.00 am – 10.30 am	Break	Discussions expected to continue but informally	
	10.30 am – 01.00 pm	Inquiry-based instruction	Teachers are presented with the problem. Teachers are taught the skill of inquiry-based instruction, including demonstration of concepts.	Power point presentations
	01.00 pm – 02.00 pm	Lunch break	Teachers are allowed to break for lunch within their clusters, asked to reflect on what was learned.	
	02.00 pm – 03.00 pm	Questioning	A discussion period involving questioning and answering from both the instructor and the teachers	
	03.00 pm – 04.30 pm	Problem solving	Teachers go into their clusters, solve the problems provided by the researcher.	The problem to be solved projected

Table 3

Day 3 (of 3) activities for the training

Day	Time	Activity	Details about the activity	Materials
Day 3	08.30 am - 10.00 am	Evaluation (Inquiry-based instruction)	Teachers report on how they practice the authentic instruction skill, discuss challenges, support, immediate outcomes, and seek support.	
	10.00 am – 10.30 am	Break	Discussions expected to continue but informally	
	10.30 am – 01.00 pm	Higher order questioning and argumentation	Teachers are presented with the problem. Teachers are taught the skill of higher order questioning and argumentation, including demonstration of concepts.	Power point presentations
	01.00 pm – 02.00 pm	Lunch break	Teachers can break for lunch within their clusters, asked to reflect on what was learned	
	02.00 pm – 03.00 pm	Questioning	A discussion period involving questioning and answering from both the instructor and the teachers	
	03.00 pm – 04.30 pm	Problem solving	Teachers go into their clusters, solve the problems provided by the researcher.	The problem to be solved projected

achievement. The process implies that the role of the students, therefore, is to cooperate in the delivery of the new instructional strategies.

According to Leibowitz, Bozalek, van Schalkwyk, and Winberg (2015), leadership that is supportive and informed is vital in ensuring the uptake of PD by teachers. Successes often occur when a pedagogical leader's or mentor's vision entails the building of staff capacity and is willing to support growth and execution of new ideas (Brown & Inglis, 2013). The responsibility of making sure that the teaching staff is able to adapt to change and to deal with the uncertainties that come with it is placed on good leadership (Brown & Inglis, 2013). Management that is supportive therefore can impact PD programs' effectiveness.

Research conducted among schools that are successful indicated that the principals of such schools spent considerable time enhancing the teaching and learning dimensions of the schools (Bellibaş, 2015). Administrative support in itself does not increase student motivation but sustains the process of this increase through new instructional strategies. Such efforts in instructional leadership include the setting of academic goals, assessment of the effectiveness of the instructional strategies of teachers, development of curricula, and provision of opportunities for instructional enhancement (Bellibaş, 2015).

For this project, the role of the school leadership will involve allowing the participants both to engage in the PD and to practice the new instructional strategies in their classrooms. The less experienced science teachers' role will be to learn from the experienced teachers and to join in the newly created professional community. Lastly, the other teachers will have a role in the promotion of the new instructional strategies through providing baseline moral support.

Project Evaluation

The traditional way of evaluating PD has been through assessing the teachers' level of satisfaction by use of questionnaires. Program evaluation is important as it enables teachers to recognize whether they benefitted from the PD program and whether they were able to implement the concepts learned in the classroom. However, this kind of evaluation misses out on the core purpose of the PD program. Although teachers can comment on whether the program was satisfactory or not, they do not have the opportunity to tell whether following the application of what was learned would truly result in the improvement of standardized scores. Also, for traditional one-day workshops, teachers may give a false impression that they were satisfied with the program, when in essence, their perception is that the content could have been sent in an email, thus indicating a feeling of wasted time sitting through the PD.

No long-term evidence exists regarding the consistency of evaluation of PD programs or their outcomes. While some programs survey the satisfaction of the supervising administrators of persons who attend the PD programs, others suggest that student achievement is an indicator of the success of PD (Stewart, 2014). In this way, both qualitative and quantitative measures can be considered. Quantitative measures include student grades and scores on standardized tests, whereas qualitative measures include attendance, attitude, and dropout among other data.

In recent years evaluating PD has shifted from assessing the number of attendees and their degree of enjoyment of the workshop to the determination of whether the PD program has had an impact on student achievement (Koellner & Jacobs, 2015). The latter assessment of PD is inclusive of its processes at all levels. These levels include combining simple tools for the assessment of specific activities and greater analysis of the effectiveness of teachers and the progress of student learning.

Battersby and Verdi (2015) indicated the evaluation of teachers should be inclusive of numerous performance measures as well as the improvement of the student test scores. The implication is that there is a need to develop a way of evaluating PD that captures the objectives of the program and assesses if and how the core issues were addressed. The current project includes evaluations to comprise four different levels: reaction, behavior, learning, and results, to be carried out at varying time intervals following the end of each of the training sessions and continued even after the end of the training (Appendix D).

Reaction. The first level of the evaluation will request feedback from the participants at the end of the training session. This evaluation will seek to identify the relevance, completeness, usefulness of the material, and the level of engagement of the participants in the PD training. The purpose of evaluating the participants' reactions is to establish customer satisfaction. Even if participants give false feedback, the information will still be considered important. This kind of feedback will be regarded as useful for making any needed changes to insure the remaining sessions are more productive. Therefore, an evaluation sheet will be provided to the teachers at the end of each training session. To reduce the element of misinformation, the questionnaires will be open ended, which will allow the teachers to express their opinion on the delivery, time involved, usefulness of the session, and whether the problems given in their discussions were relevant to the situations in the classrooms. The questionnaires will also give the teachers a chance to provide other comments.

Learning. The second level will evaluate, learning, takes place only following the demonstration phase of the target skill. An evaluation will be completed shortly after the completion of the PD program or after returning to the respective institutions. Given that the delivery of the PD will be cyclical in nature and will involve several one-day training and discussions sessions, with the rest of the days of the week for practice in their classrooms, feedback will be communicated electronically or through the support platforms.

The teachers are expected to be actively communicating and collaborating with one another, sharing their challenges and successes they are experiencing with the implementation of the strategies taught. Therefore, time will be given in the morning PD sessions before a new concept is introduced for the participants to provide a summary of what they had learned after practicing the previous strategy. Teachers' summaries will be sufficient for evaluating ongoing learning after each session.

Behavior change. The third level of evaluation will focus on behavior change, examining whether the PD training will lead to a change of behavior. Because behavior change is something that requires continuous and persistent efforts in the application of the new teaching strategies, the assessment will be divided into a number of components. First, teachers will be asked to report any changes in the timeliness of homework delivery, as well as completeness and accuracy levels. Hypothetically, the use of interactive homework would change the attitudes of students and their families toward longer time and more engaging homework.

For assessing impact on higher order thinking, teachers will be asked to provide feedback on the level of student engagement in terms of students' ability to present correct and well-supported arguments. Engagement will be measured by students' ability to ask intelligent questions that denoted prior reading or a deep interest in the subject discussed and their interest in conducting more experiments or activities related to the taught subject. Teachers who are interested and engaged will reflect development of inner motivation and drive toward studying science not just for the grades, but for a greater reason promoting extra effort.

Results. The last level of assessment will involve examining results regarding whether the PD program achieves its intended objectives. The objectives of the current PD are four-fold: enabling teachers to understand the link between motivation and instructional strategies that take into account the developmental and the operational level of students; developing a theoretical understanding of the new instructional strategies as the solution to the current deficiencies; developing the teachers' confidence in the application of the new instructional strategies; and providing monitoring and support in order to achieve student improvement in standardized test scores. While the first three objectives could be assessed after the end of the PD program, the last objective will be long term and can only be assessed following the end of the academic year. Through the feedback provided from the learning sessions, I may be able to derive information regarding whether the objectives were fulfilled.

Implications Including Social Change

Following the completion of the PD program, changes among teachers and students are expected. In the first place, sharing and the collaborative activities are expected to improve relationships among teachers. Moreover, it is expected that teachers will go beyond just conveying information to their counterparts who did not take part in the study to providing coaching and mentorship, especially for incoming teachers. Furthermore, it is expected that teachers will not only seek to share information on pedagogical strategies and student response but will seek an understanding of content among themselves, thus increasing their content specific competencies.

For the students, it is expected that the changes in the delivery of content in the classroom will change their perception of science as a subject. If this change is realized, it is also expected that students will consider careers associated with science, and thus develop greater interest and an inner drive toward the study and research of scientific issues. Moreover, it is expected that through having an opportunity to interact with the teachers through argumentation and questioning, that the teacher-student relationship will significantly improve. With the improvement in this relationship, it is also expected that students will gain greater confidence and self-efficacy pertaining to the comprehension of science, and in the end exhibit higher test scores.

Local Community

The enhancement of teacher-student relationships and the change in the homework practices will be beneficial to the community in several ways. First, it is expected that there will be a change in behavior that emanates from increased focus and discipline coming through having meaningful goals and objectives. When students have identified their vision for the future, they are likely to concentrate on it and as such more readily avoid engaging in criminal behavior and unhealthy acts such as smoking illegal drugs.

It is also expected that with the enhancement of the homework practices, students' relationship with their parents will improve. Interactive homework is designed to enable the engagement of the students' families in their studies without interfering. Such engagement is beneficial for the relationship between students and their family members. Aside from just engagement, because the homework is given an allowance of sufficient time, family time can be increased, improving communication between parents and students, and encouraging positive values.

Far-Reaching

The expectations of far reaching implications are applicable for peer training in and the use of the strategies learned during the current PD. It is expected that following the achievement of the long-term success desired, the PD that was conducted in two schools will serve as a pilot study from which strategies can be adopted. However, such adoption must take into account the variations in the contextual factors if the strategies will work ideally.

Conclusion

Following the identification of the lack of intrinsic motivation as the major hindrance to student achievement in science, and the identification of several instructional strategies as the solution to the same, the current project will adopt PD training to address these. The aim of the PD will be to enhance the teachers' skills and capability to motivate students toward science learning and achievement through higher order instructional strategies like questioning, argumentation, authentic instruction, and interactive homework. Higher order instructional strategies may be achieved through a multi-modal design that will incorporate student-centered, experiential, reflective and problem-based learning.

The program will be conducted for three weeks, incorporating a one-day session each week. In each of the sessions, emphasis will be given in the theoretical grounding of the teachers' pedagogical strategy, followed by a period of demonstration of the concepts, and discussions that will be tailored to solve related problems. A collaboration among the teachers will be initiated through clustering teachers into their subject groups and requiring them to hold discussions and share issues within their clusters. Moreover, the teachers are expected to practice the concepts learned in their classrooms during their normal lessons and share the challenges and successes experienced with each other in a bid to find solutions. I will provide support, although this will be purposely limited to transfer dependency from myself to the collaborative group for long term sustainability of the project.

To ensure the objectives of the project will be fulfilled in a satisfactory manner, assessments will be cyclical, continuous, and covering every aspect from teacher satisfaction to the needed changes in the students. Assessments will be given at the beginning of every session (for summarizing and reporting), after training sessions (for the evaluation of that session), during practice periods (for enabling the adaptation of the strategies geared to the contextual issues), and the final assessment will be conducted one year after the end of the PD (for reporting academic achievement).

Although several barriers may be identified pertaining to the proliferation of skills and strategies acquired during the PD program, this program has a number of potential implications. First, it has the potential of resulting in continued and sustained professional communities with mentorship among the teachers. The program also has the capability of enhancing student behavior and student relationships with teachers, parents, and even between teachers and parents.

Section 4: Reflections and Conclusions

Introduction

In the reflections and conclusions section I present a personal view of the project. First, I summarize the project strengths and limitations. Next, I present my individual experience as the researcher in the project development process. Furthermore, I discuss the potential impacts of the project, its implications, application, as well as direction for future research.

Project Strengths

The professional development (PD) program I designed for this project has several strengths. First, I designed the project to integrate various models. In isolation, the models may not enable the delivery of effective PD, even if quality criteria are met. Therefore, bringing together different models may increase the activity of the teachers, but also makes the learning experiences more meaningful and fulfilling (Chow, 2016). Various models of PD include teacher-centered PD, reflective PD, experiential PD, and problem-based learning. The support for social-constructivist models stems from the emphasis that PD is most useful when it places emphasis on active teaching, observation, evaluation, and reflection (Matherson & Windle, 2017).

A second strength is the project can fit well into the normal routines and the work of the teachers. Egalite and Kisida (2018) agreed that educators can be overwhelmed with all of their daily responsibilities in the classroom, which impacts their motivation to participate in PD during the school day. In the current PD program design, care was taken to ensure that teachers can take part in the PD without neglecting their school duties. Teachers will be empowered and then released to design their actual classroom lessons and homework through the strategies taught.

Lastly, the design of the PD program took into account the need for future sustainability even after I withdraw from the project. Ho and Arthur-Kelly (2013) described a professional learning community as an environment that fosters mutual cooperation, personal growth, emotional support, and synergy of effort. As such, these communities will continue to be useful in the future. Professional learning that is only implemented for a short period will not display the optimum success; however, it has to be designed in such a way that it will continue to be used throughout the school year (Kazu & Demiralp, 2016).

I designed sustainability through collaboration and the formation of learning communities, and through engaging various support systems that would be required by the teachers (Gutierez & Kim, 2017). First, within the delivery of the PD, I will cluster teachers into supportive groups and will provide them with relevant problems to solve, which will provide them with the chance to meet, interact both formally and informally, and develop a sense of trust and openness that thrusts them into sharing their experiences during practice. Learning by teachers takes place when they do the activity, read, and reflect; through collaboration with other teachers; close examination of students and what they do; and shared observations with other teachers (Burke, 2013).

Pertaining to support systems, the involvement of other teachers from varied disciplines and the school administration provides diversity of resources through which teachers could receive support during the implementation process. Although the initial support involves allowing the teachers to attend the program, future support would be through the unified ways of enacting discipline among students. The strategies learned can foster relationships, which could provide the support needed for teachers who must exert extra effort in the design of their classroom and homework experiences through the new pedagogical strategies.

Recommendations for Remediation of Limitations

Based on the barriers to the proliferation of the pedagogical strategies acquired during the PD, I recommend the following steps be taken. First, Uslu (2017) indicated a need to prepare the school administration for the expected short-term and long-term changes, explaining the support that might be required. This preparation would help in winning administration support, which is vital if the program will work in a different context.

There is a need for understanding teachers' professional needs and their current work situations before involving them in the PD. Teachers need significant professional support in the implementation of strategies that enhance higher order learning (Chee, Mehrotra, & Ong, 2015). Because the implementation of the project requires extra effort from the teachers, overworked and demotivated staff may find it difficult to adopt. Therefore, Ma, Xin, and Du (2018) recommended to avoid failure, such persons need to be identified and vetted, so the program is conducted for persons who have a higher chance of implementing the changes in the long term.

Lastly, clustering teachers for achieving collaboration is important. Peltola, Haynes, Clymer, McMillan, and Williams (2017) noted the clustering will foster relationships within the school and among other schools. These relationships can begin to resolve any fragmentations in relationships within and between schools and to ensure that only teachers who can share and collaborate are put together. Teacher collaboration can ideally be done by requesting teachers to classify themselves into pertinent categories, such as type of science courses they teach.

Recommendations for Alternative Approaches

I also considered a curriculum plan as a project genre. However, the targeted county is in the process of adapting the curriculum. Therefore, it was more beneficial to choose the PD project study. Furthermore, the data analysis revealed that teachers are interested in knowing how to implement instructional strategies to help students learn science. PD programs can help teachers learn by allowing them to get a visual ideal of the strategies by modeling. Allowing them to give their insight or questions will enable them to incorporate the strategy. Prior to my study, teachers were already using a curriculum plan mandated by the targeted county; however, the study results showed teachers needed more than just an outline of objectives and content standards. They need PD to help them learn know how to implement strategies to help students improve in science. Hopefully, my study's results will provide additional information that will possibly assist with writing the science curriculum.

Scholarship

Reflecting on the research aspect of my study, I was enlightened by all the perceptions and studies that helped to identify why eighth-grade students have low academic performance in middle school science. Initially, I was appalled that these targeted schools consistently showed no progress in eighth-grade students being proficient in science. However, I became more interested in determining why these students were not making progress, and if there was a solution that could assist teachers in helping these students be successful in science.

When I began to create the PD program, I thought about how easy the strategies were to facilitate in my own classroom. However, I imagine there may be a big difference when teachers assume the role of students and when the entire teaching process is observed from a different perspective. More particularly, when I interviewed the participants and developed the project, I was able to reflect on my own experience of being a teacher, and my experience with PD programs. First, I was able to relate to how passionate the teachers were about their students' success and wanting to help them succeed. During the interview process, I encountered many different perceptions about what it takes for students to be successful, how teachers understood the content, and how they analyzed what they needed to be more effective as teachers. I realized that we all have different rates of understanding.

However, with these differences, finding a way to reach the common goal of student success was everyone's objective. The data from the interviews revealed that many participants had the desire to use more engaging ways to deliver instruction; however, they realized that to be current with a constantly changing world, perhaps PD may help them. I began to think of how I could design a PD program that could help teachers learn engaging strategies, while ensuring they would not get bored by discussions that did not appear to be intellectually stimulating. PD can seem like a waste of time, especially if teachers cannot see the benefit in what being taught. However, with input from teachers regarding what they need, designing a PD program that will be beneficial became easier.

Project Development and Evaluation

Project development was not as easy as I had previously thought. First, I had to approach schools and find teachers that would be willing to participate in my interviews, which was a very humbling experience. From their feedback, I was able to determine the themes and connect these themes to reveal the possible solution to the problem. It took me months of studying to finally come up with my plan. I had no idea that so much work was involved with creating a PD program for teachers. It was a learning process for me, as I came to realize that I had to give up my power to control the entire program, and I had to come up with a design that will allow teacher-centered PD. In the past, I would have wanted to take control of the entire project. However, I realized that if I did that, my training sessions would be nothing more than the traditional ones, which I myself criticized. I realized that change begins from the inside.

For evaluation, I develop the strategies that would best connect the teachers' perceptions revealed in the interviews. During the interviews some teachers did say that they had never been taught how to use a specific strategy but had just been given the material to implement it. Specifically, a few participants did not want to speak negatively about the targeted district, so they chose not to elaborate on this topic. Furthermore, even though I could get some teachers to expand on the question, I learned to be patient and to appreciate the amount of effort that the teachers had already put into their responses. Hopefully, the exposure to new strategies through the proposed PD, and the demonstration of how to effectively implement strategies, will boost teachers' confidence and help their students be more engaged in learning.

Leadership and Change

I learned that change begins from the inside. I presented the problem and instead of shifting the blame to the students, helped the participants to see that there is something the teachers can do about it, which will stimulate individual change in the students. I also learned that although I can change as an individual, the sustainability of that change is dependent on the system-wide efforts. As such, I realized how important it is to involve other members of the staff and school leadership in the PD. Their moral support and the approval of the new strategies will be a great source of motivation for the teachers.

Analysis of Self as Scholar

As a scholar, I learned I do not know everything. I literally had to change my approach to thinking. I had to approach the problem not knowing what the solution would be. Being sure I was prepared do the research and expand my knowledge, I found myself occasionally being discouraged because everything I previously thought I knew about education slowly started to change as I did more research. Furthermore, conducting interviews was something I never thought I would be able to do. There was so much I had to consider as it relates to confidentiality, ethics, and upholding the university's expectations in conducting research. I know I could not have completed my study without the foundational courses that I received from Walden University.

Analysis of Self as Practitioner

As a practitioner in the field of education, I learned that it is no longer sufficient to focus solely on the 30 students I teach daily. I have learned that typically when students do not achieve, there is a bigger issue at hand. However, before attending Walden University, I simply did not have expertise needed to deal with issues on a district level. Attending Walden University has equipped me to tackle big issues, through research and designing a possible solution to a problem. I never thought I was capable of such as task, as it has taken years of research to understand the hard work that goes into being the leader of change. Furthermore, my professors at Walden University helped me attain the knowledge needed to have the solid foundation in research to carry out such a difficult task. The positive encouragement helped me to stay focused and not to give up.

Analysis of Self as Project Developer

Project development entails a great deal of planning. I learned that at the backbone of every successful project are months of examining every detail. If those details and especially their workability are not considered, then the project is bound to fail. I also learned it is important to have feedback mechanisms within the project design. Interviewing teachers and hearing what they had to say revealed the importance of taking their opinions into consideration, so I could create something beneficial and possibly have a solution to why students are not achieving in science.

The Project's Potential Impact on Social Change

The current project has the potential to impact several social changes. The social change comes from the various relationships that may be spurred by the PD program's delivery and implementation. First, the collaboration among teachers may increase their connection and communication. Secondly, the support of teachers of other subjects may help in fostering system-wide collaboration.

[[The above was the last page I edited thoroughly, so please be sure to continue through this section and make the appropriate changes, as they are indicated above.]]

In the implementation of the project, it is expected that other relationships will improve. These include relationships between students, between parents and students, and between parents and teachers. Key to these improvements are class discussions and the interactive homework. The improved relationships are expected also to lead to improved behavior among students, which is beneficial to society. When all of these are transferred to different schools, both within and outside the district, far reaching harmonious relationships among the scholarly community and among the members of the general society may result.

Implications, Applications, and Directions for Future Research

Future research needs to identify ways through which strategies that are not context sensitive can be realized for the improvement of students' science achievement. The uncertainty of the long-term impacts and sustainability could be a limitation of this study. The limitation of this study was in relation to the capability of sustaining the changes in pedagogy, especially because they require extra effort from the teachers. Furthermore, change is a slow, steady process; therefore, changes in student scores may not be immediate. Ssignificant changes may only be realized after one year. Future research should therefore devise strategies that can be delivered in ways that do not require much effort, thereby promoting their long-term use.

Conclusion

The current project possesses several strengths as well as limiting factors. Project strengths include the ability for teachers to learn how to implement strategies in their classroom. They have to keep in mind that it may take multiple times of using a strategy before it is effectively executed. Also, teachers have to be aware of their teaching styles, finding what works best for them to assist their students' learning. The interviews gave me an opportunity to hear teachers' concerns for their students, as well as allow them to offer insight to help with the overall success of teaching eighth-grade science. The range of teaching experiences provided valuable data, as the variety of subjects and years of experience provided rich insights into their perceptions.

Furthermore, the documents that I reviewed helped me to see why these teachers struggled with engaging their students. The state curriculum guide did provide objectives and what needed to be taught for subject areas. However, the guide did not have strategies the teachers could use to engage students, nor interactive activities for the students to practice concepts. Last, I had the opportunity to research each of the themes identified in the data results and gain insights from researchers and evidence-based practices that would help students learn and be successful. The interviews, documents, and literature presented hope for what can be achieved in the long run. The interviews, documents, and literature also presented hope that the desired changes can be realized. This project study has taught me as a scholar, project developer, and practitioner. Indeed, this study was more than a project. It was a true learning experience.

References

Abdi, A. (2014). The effect of inquiry-based learning method on students' academic achievement in science course. *Universal Journal of Educational Research*, *2*(1), 37-41. https://doi.org/10.13189/ujer.2014.020104

Acar, İ. H., & Yıldız, S. (2016). Professional development of elementary school teachers through online peer collaboration: A case study. *Turkish Online Journal of Qualitative Inquiry*, *7*(4), 422-439. https://doi.org/10.17569/tojqi.79480

Ahmed, A. G. A. (2013). The impact of learning by teaching strategy on university students' linguistic competence. *University of Bakht Alruda Scientific Journal*, *9*, 185–200.

Akers, R. (2017). A journey to increase student engagement. *Technology & Engineering Teacher*, *76*(5), 28-32.

Akiba, M. & Liang, G. (2016). Effects of teacher professional learning activities on student achievement growth. *Journal of Educational Research*, *109*(1), 99-110. https://doi.org/10.1080/00220671.2014.924470

Amrein-Beardsley, A. (2012). Recruiting expert teachers into high-needs schools: Leadership, money, and colleagues. *Education Policy Analysis Archives*, *20*(27), 71-91. https://doi.org/10.14507/epaa.v20n27.2012

Archer-Bradshaw, R. E. (2015). Teaching for scientific literacy? An examination of instructional practices in secondary schools in Barbados. *Research in Science Education*, *47*(1), 67-93. https://doi.org/10.1007/s11165-015-9490-x Aremu, M. A., Gbadeyan, R. A., Sofoluwe, A. O., & Aremu, M. A. (2015). Influence of homework on students' motivation and performance. *Humanities & Social Sciences*, 127.

Ariës, R. J., & Cabus, S. J. (2015). Parental homework involvement improves test scores? A review of the literature. *Review of Education*, *3*(2), 179-199. https://doi.org/10.1002/rev3.3055

Ashford-Rowe, K., Herrington, J., & Brown, C. (2014). Establishing the critical elements that determine authentic assessment. *Assessment & Evaluation in Higher Education*, *39*(2), 205-222. https://doi.org/10.1080/02602938.2013.819566

Aslan, S. (2015). Is learning by teaching effective in gaining 21st century skills? The views of pre-service science teachers. *Educational Sciences: Theory & Practice*, *15*(6), 1441-1457. https://doi.org/10.12738/estp.2016.1.019

Asterhan, C. S., & Babichenko, M. (2015). The social dimension of learning through argumentation: Effects of human presence and discourse style. *Journal of Educational Psychology*, *107*(3), 740. https://doi.org/10.1037/edu0000014

Barattucci, M. M. (2017). Approach to study as an indicator of the quality of teaching and of learning environment: The contribution of John Biggs. *Journal of E-Learning & Knowledge Society*, *13*(2), 77-88. https://doi.org/10.20368/1971-8829/1311

Barrouillet, P. (2015). Theories of cognitive development: From Piaget to today. *Developmental Review*, *38,* 1-12. https://doi.org/10.1016/j.dr.2015.07.004

Battersby, S. L., & Verdi, B. (2015). The culture of professional learning communities and connections to improve teacher efficacy and support student learning. *Arts Education Policy Review*, *116*(1), 22-29. https://doi.org/10.1080/10632913.2015.970096

Bayar, A. (2014). The components of effective professional development activities in terms of teachers' perspective. *International Online Journal of Educational Sciences, 6*(2), 319-327. http://dx.doi.org/10.15345/iojes.2014.02.006

Beilin, H., & Pufall, P. B. (2013). *Piaget's theory: Prospects and possibilities*. New York, NY: Norton.

Bellibaş, M. S. (2015). Principals' and teachers' perceptions of efforts by principals to improve teaching and learning in turkish middle schools. *Educational Sciences: Theory & Practice*, *15*(6), 1471-1485. https://doi.org/10.12738/estp.2016.1.0009

Bender, E., Hubwieser, P., Schaper, N., Margaritis, M., Berges, M., Ohrndorf, L., . . . Schubert, S. (2015). Towards a competency model for teaching computer science. *Peabody Journal of Education (0161956X)*, *90*(4), 519-532. https://doi.org/10.1080/0161956X.2015.1068082

Bhattacharyya, S., Junot, M., & Clark, H. (2013). Can you hear us? Voices raised against standardized testing by novice teachers. *Creative Education, 4*(10), 633-639. https://doi.org/10.4236/ce.2013.410091

Bianchini, J. A., & Solomon, E. M. (2013). Constructing views of science tied to issues of equity and diversity: A study of beginning science teachers. *Journal of Research in Science Teaching*, *12*(2), 41-45. https://doi.org/10.1002/tea.10060

Bilgin, A., & Balbag, M. Z. (2016). Personal professional development efforts scale for science and technology teachers regarding their fields. *Acta Didactica Napocensia*, *9*(2), 67-78.

Bintz, W. P. (2011). Teaching vocabulary across the curriculum. *Middle School Journal, 42*(4), 44-53. https://doi.org/10.1080/00940771.2011.11461773

Blair, D. J. (2016). Experiential learning for teacher professional development at historic sites. *Journal of Experiential Education*, *39*(2), 130-144. https://doi.org/10.1177/1053825916629164

Bogdan, R. C., & Biklen, S. (2007). *Qualitative research for education: An introduction to theories and methods* (5th ed.). Boston, MA: Allyn and Bacon.

Boström, J., Yacoub, A., & Schramm, J. (2010). Prospective collection and analysis of error data in a neurosurgical clinic. *Clinical Neurology and Neurosurgery, 112*(4), 314-9. http://dx.doi.org/10.1016/j.clineuro.2010.01

Brickman, S. J., Alfaro, E. C., Weimer, A. A., & Watt, K. M. (2013). Academic engagement: Hispanic developmental and non-developmental education students. *Journal of Developmental Education*, *37*(2), 14.

Brígido, M., Borrachero, A. B., Bermejo, M. L., & Mellado, V. (2013). Prospective primary teachers' self-efficacy and emotions in science teaching. *European Journal of Teacher Education*, *36*(2), 200-217. https://doi.org/10.1080/02619768.2012.686993

Broad, J. H. (2015). So many worlds, so much to do: Identifying barriers to engagement with continued professional development for teachers in the further education and training sector. *London Review of Education*, *13*(1), 16-30. https://doi.org/10.18546/LRE.13.1.03

Broks, A. (2014). Scientific thinking: The backbone of modern science and technology education. *Journal of Baltic Science Education*, *13*(6), 764-766.

Brown, A., & Inglis, S. (2013). So what happens after the event? Exploring the realisation of professional development with early childhood educators. *Australasian Journal of Early Childhood, 38*(1), 11.

Brown, G. (2013). Piaget's theory and educational psychology. In S. Modgil, C. Modgil & G. Brown (Eds.), *Jean Piaget: An interdisciplinary critique* (pp. 94-97). New York: Routledge.

Brownell, S. E., Price, J. V., & Steinman, L. (2013). Science communication to the general public: Why we need to teach undergraduate and graduate students this skill as part of their formal scientific training. *Journal of Undergraduate Neuroscience Education, 12*(1), E6–E10. PMid:24319399

Burke, B. M. (2013). Experiential professional development: A model for meaningful and long-lasting change in classrooms. *Journal of Experiential Education*, *36*(3), 247-263. https://doi.org/10.1177/1053825913489103

Bursal, M. (2013). Longitudinal investigation of elementary students' science academic achievement in 4-8th grades: Grade level and gender differences. *Educational Sciences: Theory & Practice*, *13*(2), 1151-1156.

Can, G. (2010). Nursing education in Turkey. *Nurse Educator*, *35*(4), 146-147. https://doi.org/10.1097/NNE.0b013e3181e337eb

Carillo, M. R., & Papagni, E. (2013). Is the 'globalization' of science always good for scientific productivity and economic growth? *Metroeconomica, 64*(4), 607-644. http://dx.doi.org/10.1111/meca.12023

Carpenter, J. P., & Krutka, D. G. (2015). Engagement through microblogging: Educator professional development via Twitter. *Professional Development in Education*, *41*(4), 707-728. https://doi.org/10.1080/19415257.2014.939294

Carson, K. & Dawson, V. (2016). A teacher professional development model for teaching socioscientific issues. *Teaching Science: The Journal of the Australian Science Teachers Association*, 62 (1), 30-37.

Casey, P. J., Starrett, T. M., & Dunlap, K. (2013). Residual effects of a professional development project for aspiring school leaders. *Academy of Educational Leadership Journal, 17*(2), 81.

Cavas, B., Cavas, P., Karaoglan, B., & Kisla, T. (2009). A study on science teachers' attitudes toward information and communications technologies in education. *Online Submission 5*(1), 47-52.

Cebesoy, Ü. B., & Öztekin, C. (2016). Relationships among Turkish pre-service science teachers' genetics literacy levels and their attitudes toward issues in genetics literacy. *Journal of Baltic Science Education*, *15*(2), 159-172.

Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40-year meta-analysis. *Psychological Bulletin*, *140*(4), 980-1008. https://doi.org/10.1037/a0035661

Cervetti, G. N., Barber, J., Dorph, R., Pearson, P. D., & Goldschmidt, P. G. (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of Research in Science Teaching*, *49*(5), 631-665. https://doi.org/10.1002/tea.21015

Cetin, P. S. (2014). Explicit argumentation instruction to facilitate conceptual understanding and argumentation skills. *Research in Science & Technological Education*, *32*(1), 1-20. https://doi.org/10.1080/02635143.2013.850071

Chan, Z. C. Y., Fung, Y., & Chien, W. (2013). Bracketing in phenomenology: Only undertaken in the data collection and analysis process? *The Qualitative Report, 18*(30), 1-9. Retrieved from http://search.proquest.com/docview/1505321230?accountid=2163

Chee, Y. S., Mehrotra, S. & Ong, J. C. (2015). Professional development for scaling pedagogical innovation in the context of game-based learning: teacher identity as cornerstone in "shifting" practice. *Asia-Pacific Journal of Teacher Education*, *43*(5), 423-437. https://doi.org/10.1080/1359866X.2014.962484.

Chen, Y-C., Lin, J-L., & Chen, Y-T. (2014). Teaching scientific core ideas through immersing students in argument: Using density as an example. *Science Activities*, *51*(3), 78-88. https://doi.org/10.1080/00368121.2014.915792.

Chiang, T. H., Yang, S. J., & Hwang, G. J. (2014). An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities. *Journal of Educational Technology & Society*, *17*(4), 352.

Chikasanda, V. K. M., Otrel-Cass, K., Williams, J. & Jones, A. (2013). Enhancing teachers' technological pedagogical knowledge and practices: A professional development model for technology teachers in Malawi. *International Journal of Technology and Design Education*, *23*(3), 597. https://doi.org/10.1007/s10798-012-9206-8

Childs, A., Sorensen, P., & Twidle, J. (2011). Using the Internet in science teaching? Issues and challenges for initial teacher education. *Technology, Pedagogy and Education, 4*(2), 21-26. https://doi.org/10.1080/1475939x.2011.588413

Chinn, P (2012). Looking through the lenses of science literacy and cultural diversity: Learning from Helena's mistake. *Cultural Studies of Science Education, 7*(2), 441-446. https://doi.org/10.1007/s11422-012-9378-2

Chow, A. W. (2016). Teacher learning communities: The landscape of subject leadership. *International Journal of Educational Management, 30*(2), 287-307. https://doi.org/10.1108/IJEM-07-2014-0105

Chumbley, S. B., Haynes, J. C., & Stofer, K. A. (2015). A measure of students' motivation to learn science through agricultural STEM emphasis. *Journal of Agricultural Education, 56*(4), 107-122. https://doi.org/10.5032/jae.2015.04107

Cocco, M., & Tuzzi, A. (2013). New data collection modes for surveys: A comparative analysis of the influence of survey mode on question-wording effects. *Quality and Quantity, 47*(6), 3135-3152. http://dx.doi.org/10.1007/s11135-012-9708-

Conner, L., & Sliwka, A. (2014). Implications of research on effective learning environments for initial teacher education. *European Journal of Education*, *49*(2), 165-177. https://doi.org/10.1111/ejed.12081

Corbin, A. (2017). Assessing differences in learning styles: Age, gender and academic performance at the tertiary level in the Caribbean. *Caribbean Teaching Scholar*, *7*67-791.

Cordingley, P., Higgins, S., Greany, T., Buckler, N., Coles-Jordan, D., Crisp, B.. . . & Coe, R. (2015). *Developing great teaching: lessons from the international reviews into effective professional development.* Teacher Development Trust.

Crawford, B. A. (2013). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching*, *12*(7), 180-191. https://doi.org/10.1002/ tea.20157

Creswell, J. (2013). *Qualitative inquiry and research design: Choosing among five approaches*. Los Angeles, CA: Sage Publications.

Crouch, M., & McKenzie, H. (2006). The logic of small samples in interview-based qualitative research. *Social Science Information, 45*(4), 483-499. https://doi.org/10.1177 /0539018406069584

Demirbag, M., & Gunel, M. (2014). Integrating argument-based science inquiry with modal representations: Impact on science achievement, argumentation, and writing skills. *Educational Sciences: Theory and Practice*, *14*(1), 386-391. https://doi.org/10.12738/estp.2014.1.1632

DeMonte, J. (2013). *High-quality professional development for teachers: Supporting teacher training to improve student learning.* Center for American Progress.

De Naeghel, J. (2012). Students' autonomous reading motivation: A study into its correlates and promotion strategies in late elementary classrooms (Unpublished doctoral dissertation). Ghent University, Ghent, Belgium.

De Naeghel, J., Van Keer, H., Vansteenkiste, M., & Rosseel, Y. (2012). The relation between elementary students' recreational and academic reading motivation, reading frequency, engagement, and comprehension: A self-determination theory perspective. *Journal of Educational Psychology, 104*(4), 1006–1021. https://doi.org/10.1037/a0027800

Derri, V., Vasiliadou, O., & Kioumourtzoglou, E. (2015). The effects of a short-term professional development program on physical education teachers' behaviour and students' engagement in learning. *European Journal of Teacher Education*, *38*(2), 234-262. https://doi.org/10.1080/02619768.2014.947024

Desimone, L., Smith, T. M., & Phillips, K. (2013). Linking student achievement growth to professional development participation and changes in instruction: A longitudinal study of elementary students and teachers in Title I schools. *Teachers College Record*, *115*(5), 1-46.

Devonshire, I. M., & Hathway, G. J. (2014) Overcoming the barriers to greater public engagement. *PLoS Biol 12*(1). https://doi.org/10.1371/journal.pbio.1001761

Dewey, J. (1932). *The later works, 1925-1953: 1932.* (J.A. Boydston, Ed.). Carbondale, Illinois: Southern Illinois University Press.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Dogru, M. (2013). The effects of peer instruction on the success, motivation and decision-making styles of primary seventh grade students. *International Journal of Academic Research, 5*(5), 299–304. https://doi.org/10.7813/2075-4124.2013/5-5/B.46

Dole, S., Bloom, L., & Kowalske, K. (2016). Transforming pedagogy: Changing perspectives from teacher-centered to learner-centered. *Interdisciplinary Journal of Problem-Based Learning*, *10*(1). https://doi.org/10.7771/1541-5015.1538

Donovan, L., Green, T. D., & Mason, C. (2014). Examining the 21st century classroom: Developing an innovation configuration map. *Journal of Educational Computing Research*, *50*(2), 161-178. https://doi.org/10.2190/EC.50.2.a

Dresser, R. (2012). The impact of scripted literacy instruction on teachers and students. *Issues in Teacher Education*, *21*(1), 71-87. Retrieved from https://scholar.google.com/

Eagleton, S. (2017). Designing blended learning interventions for the 21st century student. *Advances in Physiology Education*, *41*(2), 203-211. https://doi.org/10.1152/advan. 00149.2016

Egalite, A. J., & Kisida, B. (2018). The effects of teacher match on students' academic perceptions and attitudes. *Educational Evaluation & Policy Analysis, 40*(1), 59-81. https://doi.org/10.3102/0162373717714056

Ely, R., Ainley, M., & Pearce, J. (2013). More than enjoyment: Identifying the positive affect component of interest that supports student engagement and achievement. *Middle Grades Research Journal*, *8*(1), 13-32. Retrieved from https://scholar.google.com/

Emmer, E. T., & Evertson, C. M. (2017). *Classroom management for middle and high school teachers* (10th ed.). New York, NY: Pearson.

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem- and project-based learning. *Interdisciplinary Journal of Problem-Based Learning*, *7*(2), 128-150. http://dx.doi.org/10.7771/1541-5015.1339

Enyedy, N., & Goldberg, J. (2013). Inquiry in interaction: How local adaptations of curricula shape classroom communities. *Journal of Research in Science Teaching*, *5*(4), 10-17. https://doi.org/10.1002/tea.20131

Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, *26*(2), 43-71. https://doi.org/10.1002/piq.21143

Escobar Urmeneta, C. (2013). Learning to become a CLIL teacher: Teaching, reflection and professional development. *International Journal of Bilingual Education and Bilingualism*, *16*(3), 334-353. https://doi.org/10.1080/13670050.2013.777389

Farbman, D. A. (2015). *The case for improving and expanding time in school: A review of key research and practice.* Boston, MA: National Center on Time & Learning. Retrieved from http://timeandlearning.org.

Fitzgerald, M. M., & Theilheimer, R. (2013). Moving toward teamwork through professional development activities. *Early Childhood Education Journal*, *41*(2), 103-113. https://doi.org/10.1007/s10643-012-0515-z

Forte, A. M. & Flores, M. A. (2014). Teacher collaboration and professional development in the workplace: a study of Portuguese teachers. *European Journal of Teacher Education*, *37*(1), 91-105. https://doi.org/10.1080/02619768.2013.763791

Fosnot, C. T. (2013). *Constructivism: Theory, perspectives, and practice*. New York, NY: Teachers College Press.

Fougner, A. (2012). Exploring knowledge through peer tutoring in a transitional learning community: An alternative way of teaching counseling skills to students in social work education. *Social Work Education*, *31*(3), 287–301. https://doi.org/10.1080/02615479.2011.557431

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014) Active learning increases student performance in science, engineering, and mathematics. *PNAS, 111*(23), 8410-8415. https://doi.org/10.1073/pnas. 1319030111

Furrer, C., Skinner, E. A., & Pitzer, J. R. (2014).The influence of teacher and peer relationships on students' classroom engagement and everyday motivational resilience. *National Society for the Study of Education*, *113*(1), 101-123.

Gaikhorst, L., Beishuizen, J. J., Zijlstra, B. J. H., & Volman, M. L. L. (2015). Contribution of a professional development programme to the quality and retention of teachers in an urban environment. *European Journal of Teacher Education*, *38*(1), 41-57. https://doi.org/10.1080/02619768.2014.902439

Gamrat, C., Zimmerman, H. T., Dudek, J., & Peck, K. (2014). Personalized workplace learning: An exploratory study on digital badging within a teacher professional development program. *British Journal of Educational Technology*, *45*(6), 1136-1148. https://doi.org/10.1111/bjet.12200

Georgia Department of Education. (2017). *Curriculum and Instruction*. Retrieved from http://www.gadoe.org/Pages/Home.aspx

Georgia State Standards. (2017). *Criterion referenced competency test*. Retrieved from https://www.georgiastandards.org/Curriculum-Instruction-and-Assessment/Assessment/Pages/CRCT.aspx

Ghazi, D. R., & Ullah, K. (2015). Concrete operational stage of Piaget's cognitive development theory: An implication in learning general science. *Gomal University Journal of Research*, *31*(1), 78-89.

Glesne, C. (2011). *Becoming qualitative researchers* (4th ed.). Boston, Massachusetts: Pearson Education Inc.

Gningue, S. M., Peach, R., & Schroder, B. (2013). Developing effective mathematics teaching: Assessing content and pedagogical knowledge, student-centered teaching, and student engagement. *The Mathematics Enthusiast*, *10*(3), 621-646.

Goldhaber, D., Gratz, T., & Theobald, R. (2016, November). *Assessing the use of licensure tests as an indicator of teachers' science and mathematics content knowledge for teaching*. Panel paper presented at 2016 Fall Conference: The Role of Research in Making Government More Effective, Association for Public Policy Analysis and Management, Washington D. C.

Gonida, E. N., & Cortina, K. S. (2014). Parental involvement in homework: Relations with parent and student achievement-related motivational beliefs and achievement. *British Journal of Educational Psychology*, *84*(3), 376-396. https://doi.org/10.1111/bjep.12039

Gordon, M. (2009). Towards a pragmatic discourse of Constructivism: Reflections on lessons from practice. *Educational Studies: Journal of the American Educational Studies Association*, *45*(1), 39-58. https://doi.org/10.1080/00131940802546894

Green, T. R., & Allen, M. E. (2015). Professional development in urban schools: What do the teachers say? *Journal of Inquiry and Action in Education*, *6*(2), 53-79.

Gregory, A., Allen, J. P., Mikami, A. Y., Hafen, C. A., & Pianta, R. C. (2014). Effects of a professional development program on behavioral engagement of students in middle and high school. *Psychology in the Schools*, *51*(2), 143-163. https://doi.org/10.1002/pits.21741

Griffith, D. A. (2013). An introduction to scientific research methods in geography and environmental studies. *Geographical Analysis, 45*(4), 441-443. https://doi.org/10.1111/gean.12022

Griggs, M. S., Rimm-Kaufman, S. E., Merritt, E. G., & Patton, C. L. (2013). The Responsive Classroom approach and fifth grade students' math and science anxiety and self-efficacy. *School Psychology Quarterly*, *28*(4), 360-373. https://doi. org/10.1037/spq0000026

Gu, L., & Kristoffersson, M. (2015). Swedish lower secondary school teachers' perceptions and experiences regarding homework. *Universal Journal of Educational Research*, *3*(4), 296-305. https://doi.org/10.13189/ujer.2015.030407

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods, 18*(1), 59-82. https://doi.org/10.1177/1525822X05279903

Gutierez, S. B., & Kim, H. (2017). Becoming teacher-researchers: Teachers' reflections on collaborative professional development. *Educational Research, 59*(4), 444-459. https://doi.org/10.1080/00131881.2017.1347051

Haigen, H., & Guodong, L. (2016). Parental cultural capital and student school performance in mathematics and science across nations. *Journal of Educational Research, 109*(3), 286-295. https://doi.org/10.1080/00220671.2014.946122

Hammond, B. (2014, September 10). State scores stagnant elementary, middle and high schools overall saw flat performance in tests last year. *The Oregonian, 34*(2), 23-45. Retrieved from http://search.proquest.com/docview/1561202163?accountid=2163

Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education*, *13*(5), 1089-1113. https://doi.org/10.1007/s10763-014-9526-0

Hancock, D. R., & Algozzine, B. (2011). *Doing case study research: A practical guide for beginning researchers.* (2nd ed.). New York, NY: Teachers College Press. http://dx.doi.org/10.1080/00220671.2012.750135

Hargreaves, A. (2007). Sustainable leadership and development in education: Creating the future, conserving the past. *European Journal of Education*, *42*(2), 223-233. https://doi.org/10.1111/j.1465-3435.2007.00294.x

Hechter, R. P. (2011). Changes in pre-service elementary teachers' personal science teaching efficacy and science teaching outcome expectancies: The influence of context. *Journal of Science Teacher Education*, *8*(2), 12-19. https://doi.org/10.1007/ s10972-010-9199-7

Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L.W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching, 49*(3), 333-362. https://doi.org/10.1002 /tea.21004

Helm, C. (2017). Effects of social learning networks on student academic achievement and pro-social behavior in accounting. *Journal for Educational Research Online/Journal Für Bildungsforschung Online*, *9*(1), 52-76.

Hemphill, M. A. (2015). Inhibitors to responsibility-based professional development with in-service teachers. *The Physical Educator*, *72*, 288-306. https://doi.org/10.18666/TPE-2015-V72-I5-5756

Herrington, J., Reeves T.C., Oliver R. (2014) Authentic Learning Environments. In: Spector J., Merrill M., Elen J., Bishop M. (eds.) *Handbook of Research on Educational Communications and Technology*. New York: Springer, New York, NY. https://doi.org/10.1007/978-1-4614-3185-5_32

Hilton, A., Hilton, G., Dole, S. & Goos, M. (2016). Promoting middle school students' proportional reasoning skills through an ongoing professional development programme for teachers. *Educational Studies in Mathematics*, 92 (2), 193-219. https://doi.org/10.1007/s10649-016-9694-7.

Hitt, D. H., & Tucker, P. D. (2016). Systematic review of key leader practices found to influence student achievement: A unified framework. *Review of Educational Research*, *86*(2), 531-569. https://doi.org/10.3102/0034654315614911

Ho, F-C., & Arthur-Kelly, M. (2013). An evaluation of the collaborative mode of professional development for teachers in special schools in Hong Kong. *British Journal of Special Education, 40*(1), 22-32. https://doi.org/10.1111/1467-8578.12013

Hoekstra, A., & Mollborn, S. (2011). How clicker use facilitates existing pedagogical practices in higher education: Data from interdisciplinary research on student response systems. *Learning, Media and Technology, 37*(3), 1-18. https://doi.org/10.1080/17439884.2011.568493

Hoffman, J. L., Collins, M. F., & Schickedanz, J. A. (2015). Instructional challenges in developing young children's science concepts. *Reading Teacher, 68*(5), 363-372. https://doi.org/10.1002/trtr.1325

Hooks, B. (1990). *Yearning: race, gender and cultural politics*. Boston, MA: South End Press.

Hsu, H. Y., Wang, S. K., & Runco, L. (2013). Middle school science teachers' confidence and pedagogical practice of new literacies. *Journal of Science Education and Technology*, *22*(3), 314-324. https://doi.org/10.1007/s10956-012-9395-7

Humanities Indicators. (2016). *Reading proficiency as compared with that in science and math*. Retrieved from http://www.humanitiesindicators.org/content/indicatordoc.aspx?i=173

Hunley, S., Davies, S. C., & Miller, C. R. (2013). The relationship between curriculum-based measures in oral reading fluency and high-stakes tests for seventh grade students. *Research in Middle Level Education Online*, *36*(5), 1-8. https://doi.org/10.1080/19404476.2013.11462098

Hussain, L., Jamil, A., Noor, A., Sibtain, M., & Shah, S. M. A. (2011). Relationship between the professional attitudes of secondary school teachers with their teaching behavior. *International Journal of Academic Research in Business and Social Sciences, 1*(3), 38-46. Retrieved from http://search.proquest.com/docview/1027115650?accountid=14872

Irez, S. (2015). Are we prepared? An assessment of preservice science teacher educators' beliefs about nature of science. *Science Education*, *90*(6), 1113-1143. doi:10.1002/sce.20156

Ivey, G., & Johnston, P. H. (2013). Engagement with young adult literature: Outcomes and processes. *Reading Research Quarterly*, *48*(3), 255-275. https://doi.org/10.1002/rrq.46

Jackson, J. K., & Ash, G. (2012). Science achievement for all: Improving science performance and closing achievement gaps. *Journal of Science Teacher Education*, *23*(7), 723-744. https://doi.org/10.1007/s10972-011-9238-z

Jacob, S. & Furgerson, S. (2012). Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research. *The Qualitative Report*, *17*(6), 1-10. Retrieved from www.nova.edu/ssss/QR/QR17/jacob.pdf

Janssen, S., Kreijns, K., Bastiaens, T. J., Stijnen, S., & Vermeulen, M. (2013). Teachers' beliefs about using a professional development plan. *International Journal of Training & Development*, *17*(4), 260-278. https://doi.org/10.1111/ijtd.12016

Järvelä, S., Veermans, M., & Leinonen, P. (2008). Investigating student engagement in computer-supported inquiry: A process-oriented analysis. *Social Psychology of Education, 11, 299-322*. https://doi.org/10.1007/s11218-007-9047-6

Jegstad, K. M., & Sinnes, A. T. (2015) Chemistry teaching for the future: A model for secondary chemistry education for sustainable development. *International Journal of Science Education, 37*(4), 655–683. https://doi.org/10.1080/09500693. 2014.1003988

Ji-Wei, W., Tseng, J. C. R., & Gwo-Jen, H. (2015). Development of an inquiry-based learning support system based on an intelligent knowledge exploration approach. *Journal of Educational Technology & Society, 18*(3), 282-300.

Johnson, W. R. (2016). Why engaging in the practices of science is not enough to achieve scientific literacy. *American Biology Teacher (University Of California Press)*, *78*(5), 370-375. https://doi.org/10.1525/abt.2016.78.5.370

Kaiser, C. M., & Wisniewski, M. A. (2012). Enhancing student learning and engagement using student response systems. *Social Studies Research and Practice*, *7*(2), 137-149.

Katsioloudis, P. (2015). Aligning technology education teaching with brain development. *Journal of STEM Education: Innovations & Research, 16*(2), 6-10.

Katz, I., Eilot, K., & Nevo, N. (2014). "I'll do it later": Type of motivation, self-efficacy and homework procrastination. *Motivation and Emotion*, *38*(1), 111-119. https://doi.org/10.1007/s11031-013-9366-1

Kazantzis, N., Dattilio, F. M., Cummins, A., & Clayton, X. (2013). Homework Assignments and Self-Monitoring. *The Wiley Handbook of Cognitive Behavioral Therapy*., John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118528563.wbcbt14

Kazu, H., & Demiralp, D. (2016). Faculty members' views on the effectiveness of teacher training programs to upskill life-long learning competence. *Eurasian Journal of Educational Research*, (63), 205-224. https://doi.org/10.14689/ejer.2016.63.12

Kell, H. J., & Lubinski, D. (2013). Spatial ability: A neglected talent in educational and occupational settings. *Roeper Review*, *35*(4), 219-230. https://doi.org/10.1080/02783193.2013.829896

Kelly, D., Xie, H., Nord, C. W., Jenkins, F., Chan, J. Y., & Kastberg, D. (2013). *Performance of U.S. 15-year-old students in mathematics, science, and reading literacy in an international context: First Look at PISA 2012* (NCES 2014-024). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed. gov/pubsearch.

Kershner, R., Warwick, P., Mercer, N., & Staarman, K. J. (2014). Primary children's management of themselves and others in collaborative group work: 'Sometimes it takes patience…'. *Education 3-13*, *42*(2), 201-216. https://doi. org/10.1080/03004279.2012.670255

Khosa, D. K., & Volet, S. E. (2014). Productive group engagement in cognitive activity and metacognitive regulation during collaborative learning: can it explain differences in students' conceptual understanding? *Metacognition and Learning*, *9*(3), 287-307.

Kim, K., Sharma, P., Land, S., & Furlong, K. (2013). Effects of active learning on enhancing student critical thinking in an undergraduate general science course. *Innovative Higher Education*, *38*(3), 223-235. https://doi.org/10.1007/s10755-012-9236-x

Koballa, T. R., Glynn, S. M., & Upson, L. (2012). Conceptions of teaching science held by novice teachers in an alternative certification program. *Journal of Science Teacher Education, 16*(4), 287-308. https://doi.org/10.1007/s10972-005-0192-5

Kobold, S., Guhr, A., Kurtz, A., & Löser, P. (2015). Human embryonic and induced pluripotent stem cell research trends: Complementation and diversification of the field. *Stem Cell Reports*, *4*(5), 914–925. http://doi.org/10.1016/j.stemcr.2015.03.002

Koellner, K., & Jacobs, J. (2015). Distinguishing models of professional development: The case of an adaptive model's impact on teachers' knowledge, instruction, and student achievement. *Journal of Teacher Education*, *66*(1), 51-67. https://doi.org/10.1177/0022487114549599

Kok-Sing, T. (2016). How is disciplinary literacy addressed in science classroom? A Singaporean case study. *Australian Journal of Language & Literacy, 39*(3), 220-232.

Kola, A. J. (2013). Importance of science education to national development and problems militating against its development. *American Journal of Educational Research, 1*(7), 225-229. https://doi.org/10.12691/education-1-7-2

Komarraju, M., & Nadler, D. (2013). Self-efficacy and academic achievement: Why do implicit beliefs, goals, and effort regulation matter? *Learning and Individual Differences*, *25*, 67-72. https://doi.org/10.1016/j.lindif.2013.01.005

Koosimile, A. T., & Suping, S. M. (2015). An examination of the influence of globalization on science education in Anglophone Sub-Saharan Africa. *International Journal of Science Education*, *37*(14), 2358–2385. https://doi.org/10.1080/09500693.2015.1079667

Ku, K. Y., Ho, I. T., Hau, K. T., & Lai, E. C. (2014). Integrating direct and inquiry-based instruction in the teaching of critical thinking: an intervention study. *Instructional Science*, *42*(2), 251-269. https://doi.org/10.1007/s11251-013-9279-0

Ladd, H. F., & Sorensen, L. C. (2017). Returns to teacher experience: Student achievement and motivation in middle school. *Education Finance and Policy, 12*(2), 241-279. https://doi.org/10.1162/EDFP_a_00194

Lamanauskas, V. (2013). Natural science education importance in adolescence. *Journal of Baltic Science Education, 12*(4), 396-398.

Lecocq, C. (2015). Technology and English language learners: Can digital technology enhance the English language learning experience?. *Mount Royal Undergraduate Education Review*, *1*(3).

Le Fevre, D. M. (2014). Barriers to implementing pedagogical change: The role of teachers' perceptions of risk. *Teaching and Teacher Education*, *38*, 56-64. https://doi.org/10.1016/j.tate.2013.11.007

Lee, H., Longhurst, M., & Campbell, T. (2017). Teacher learning in technology professional development and its impact on student achievement in science. *International Journal of Science Education*, *39*(10), 1-22. https://doi.org/10.1080/09500693.2017.1327733

Lee, O., & Buxton, C. A. (2013). Teacher professional development to improve science and literacy achievement of English language learners. *Theory into Practice*, *52*(2), 110-117. https://doi.org/10.1080/00405841.2013.770328

Leibowitz, B., Bozalek, V., van Schalkwyk, S. & Winberg, C. (2015). Institutional context matters: The professional development of academics as teachers in South African higher education. *Higher Education*, *69*(2), 315. https://doi.org/10.1007/s10734-014-9777-2

Letterman, D. (2013). Students' perception of homework assignments and what influences their ideas. *Journal of College Teaching & Learning (Online)*, *10*(2), 113. https://doi.org/10.19030/tlc.v10i2.7751

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications.

Lin-Siegler, X., Ahn, J. N., Chen, J., Fang, F. A., & Luna-Lucero, M. (2016). Even Einstein struggled: Effects of learning about great scientists' struggles on high school students' motivation to learn science. *Journal of Educational Psychology*, *108*(3), 314-328. https://doi.org/10.1037/edu0000092

Lochmiller, C. R., Huggins, K. S., & Acker-Hocevar, M. A. (2012). Preparing leaders for math and science: Three alternatives to traditional preparation. *Planning & Changing, 43*(1), 198-220.

Lu, J., & Churchill, D. (2014). The effect of social interaction on learning engagement in a social networking environment. *Interactive Learning Environments*, *22*(4), 401-417. https://doi.org/10.1080/10494820.2012.680966

Lynch, M. (2013). Alternatives to social promotion and retention. *Interchange*, *44*(3/4), 291-309. https://doi.org/10.1007/s10780-014-9213-7

Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample size in qualitative interview studies: guided by information power. *Qualitative health research*, *26*(13), 1753-1760.

Mansfield, C. F., & Woods-McConney, A. (2012). I didn't always perceive myself as a "science person:" Examining efficacy for primary science teaching. *Australian Journal of Teacher Education*, *37*(10), 10. https://doi.org/10.14221/ajte.2012v37n10.5

Martin, L. E., Kragler, S., & Frazier, D. (2017). Professional development and educational policy: A comparison of two fields in education. *Journal of Educational Research and Practice*, *7*(1), 60-73. https://doi.org/10.5590/JERAP.2017. 07.1.05

Matherson, L., & Windle, T. M. (2017). What do teachers want from their professional development? Four emerging themes. *Delta Kappa Gamma Bulletin*, *83*(3), 28-32.

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach* (2nd ed.). Thousand Oaks, CA: Sage.

McConnell, T. J., Parker, J. M., & Eberhardt, J. (2013). Problem-based learning as an effective strategy for science teacher professional development. *Clearing House*, *86*(6), 216-223. https://doi.org/10.1080/00098655.2013.826486

McNamara, C. (2009). *General guidelines for conducting interviews*. Retrieved from http://managementhelp.org/evaluatn/intrview.htm

McNeill, K. L., & Knight, A. M. (2013). Teachers' pedagogical content knowledge of scientific argumentation: The impact of professional development on K–12 teachers. *Science Education*, *97*(6), 936-972. https://doi.org/10.1002/sce.21081

Mega, C., Ronconi, L., & De Beni, R. (2014). What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement. *Journal of Educational Psychology*, *106*(1), 121-131. https://doi.org/10.1037/a0033546

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation.* New York, NY: Jossey-Bass.

Michaels, S., & O'Connor, C. (2015). Conceptualizing talk moves as tools: Professional development approaches for academically productive discussion. In L. B. Resnick, C. Asterhan, & S. N. Clarke (Eds.), *Socializing intelligence through talk and dialogue* (pp. 347-362). Washington, DC: AERA. https://doi.org/10.3102/978-0-935302-43-1_27

Miller, F. A., Painter-Main, M., Axler, R., Lehoux, P., Giacomini, M., & Slater, B. (2015). Citizen expectations of 'academic entrepreneurship' in health research: Public science, practical benefit. *Health Expectations*, *18*(6), 2356-2374. https://doi.org/10.1111/hex.12205

Miller, R., Curwen, M., White-Smith, K. & Calfee, R. (2015). Cultivating primary students' scientific thinking through sustained teacher professional development. *Early Childhood Education Journal, 43*(4), 317-326. https://doi.org/10.1007/s10643-014-0656-3.

Milner, A. R., Sondergeld, T. A., Demir, A., Johnson, C. C., & Czerniak, C. M. (2012). Elementary teachers' beliefs about teaching science and classroom practice: An examination of pre/post NCLB testing in science. *Journal of Science Teacher Education*, *23*(2), 111-132. https://doi.org/10.1007/s10972-011-9230-7

Nair, S. M., Mohamed, A. R., & Marimuthu, N. (2013). Malaysian teacher trainees' practices on science and the relevance of science education for sustainability. *International Journal of Sustainability in Higher Education*, *14*(1), 71-89. https://doi.org/10.1108/14676371311288967

Naizer, G., Hawthorne, M. J., & Henley, T. B. (2014). Narrowing the gender gap: Enduring changes in middle school students' attitude toward math, science and technology. *Journal of STEM Education: Innovations & Research*, *15*(3), 29-34.

National Assessment of Educational Progress (NAEP). (2016, October 27). *The nation's report card: 2015 science at grades 4, 8, and 12.* Retrieved from http://nces.ed.gov/nationsreportcard

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

National Research Council. (2013a). *Developing assessments for the Next Generation Science Standards*. Washington, DC: National Academies Press.

National Research Council. (2013b). *Monitoring progress toward successful STEM education: A nation advancing*? Washington, DC: National Academies Press.

National Science Teachers Association. (2014). *NSTA Position Statement: Early Childhood Science Education*. Retrieved from www.nsta.org/about/positions/earlychildhood.aspx

Netterfield, T. (2011). *Scientific illiteracy: An analysis of America's silent epidemic*. Retrieved from http://www.nea.org/home/34690.html

Nevo, E., & Breznitz, Z. (2013). The development of working memory from kindergarten to first grade in children with different decoding skills. *Journal of Experimental Child Psychology, 114*(12), 217-228. http://dx.doi.org/10.1016/j.jecp.2012.09.004

Next Generation of Science Standards (NGSS) (2013). *Improving science education through three-dimensional learning.* Retrieved from http://www.nextgenscience.org/

Next Generation Science Standards Lead States (2013). *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press.

Nie, Y., Tan, G. H., Liau, A. K., Lau, S., & Chua, B. L. (2013). The roles of teacher efficacy in instructional innovation: Its predictive relations to constructivist and didactic instruction. *Educational Research for Policy and Practice*, 1-11. https://doi.org/10.1007/s10671-012-9128-y

Ma, N., Xin, S., & Du, J. (2018). A peer coaching-based professional development approach to improving the learning participation and learning design skills of in-service teachers. *Journal of Educational Technology & Society, 21*(2), 291-304.

No Child Left Behind Act of 2001 (2002). Pub. L. No.107-110, § 115 Stat. 1425.

Núñez, J. C., Suárez, N., Rosário, P., Vallejo, G., Valle, A., & Epstein, J. L. (2015). Relationships between perceived parental involvement in homework, student homework behaviors, and academic achievement: Differences among elementary, junior high, and high school students. *Metacognition and Learning*, *10*(3), 375-406. https://doi.org/10.1007/s11409-015-9135-5

Olswang, L. B., & Prelock, P. A. (2015). Bridging the gap between research and practice: Implementation science. *Journal of Speech, Language, and Hearing Research*, *58*(6), S1818-S1826. https://doi.org/10.1044/2015_JSLHR-L-14-0305

Organisation for Economic Co-operation and Development. (2014). *PISA 2012 results in focus*. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

Osborne, J., Simon, S., Christodoulou, A., Howell-Richardson, C., & Richardson, K. (2013). Learning to argue: A study of four schools and their attempt to develop the use of argumentation as a common instructional practice and its impact on students. *Journal of Research in Science Teaching*, *50*(3), 315-347. https://doi.org/10.1002/tea.21073

Ozdem-Yilmaz, Y., & Cavas, B. (2016). Pedagogically desirable science education: Views on inquiry-based science education in Turkey. *Journal of Baltic Science Education*, *15*(4), 506-522.

Özgüç, C. S., & Cavkaytar, A. (2015). Science education for students with intellectual disability: A case study. *Journal f Baltic Science Education*, *14*(6), 804-820.

Pancsofar, N., & Petroff, J. G. (2013). Professional development experiences in co-teaching: Associations with teacher confidence, interests, and attitudes. *Teacher Education and Special Education*, *36*(2), 83-96. https://doi.org/10.1177/0888406412474996

Park, D., Gunderson, E. A., Tsukayama, E., Levine, S. C., & Beilock, S. L. (2016). Young children's motivational frameworks and math achievement: Relation to teacher-reported instructional practices, but not teacher theory of intelligence. *Journal of Educational Psychology*, *108*(3), 300-313. https://doi.org/10.1037/edu0000064

Partnership for 21st Century Learning. (2015). *P21 Framework definitions*. Retrieved from http://www.p21.org/storage/documents/docs/P21_Framework_Definitions_New_Logo_2015.pdf

Pasley, J. D., Trygstad, P. J., & Banilower, E. R. (2016). Towards engagement with the science and engineering practices for all students. *Horizon Research*, 1-11. Retrieved from http://www.horizon-research.com/horizonresearchwp/wp-content/uploads/2016/04/SCIOPS-2016-NARST-Paper.pdf

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

Pehmer, A. K., Gröschner, A., & Seidel, T. (2015). How teacher professional development regarding classroom dialogue affects students' higher-order learning. *Teaching and Teacher Education*, *47*, 108-119. https://doi.org/10.1016/j.tate.2014.12.007

Peltola, P., Haynes, E., Clymer, L., McMillan, A., Williams, H. (2017). Opportunities for teacher professional development in Oklahoma rural and nonrural schools (REL 2017-273) Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest. Retrieved from http://ies.ed.gov/ncee/edlabs

Penuel, W. R., Harris, C. J., & DeBarger, A. H. (2015). Implementing the Next Generation Science Standards. *Phi Delta Kappan, 96*(6), 45-49. https://doi.org/10.1177/ 0031721715575299

Piaget, J. (1936). *Origins of intelligence in the child.* London: Routledge & Kegan Paul.

Pietri, D. M., Gurney, G. G., Benitez-Vina, N., Kuklok, A., Maxwell, S. M., Whiting, L., . . . Jenkins, L. D. (2013, October). Practical recommendations to help students bridge the research-implementation gap and promote conservation. *Conservation Biology 27*(5), 958-67. https://doi.org/10.1111/cobi.12089

Pinder, P. (2013). Exploring and understanding Maryland’s math and science teachers’ perspectives on NCLB and increase testing: Employing a phenomenological inquiry approach. *Education*, *133*(3), 298-302.

Popham, W. J. (2008). *Transformative assessment.* Association for Supervision and Curriculum Development. Alexandria, VA: ASCD Publications.

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education*, *130*(2), 241-250.

Psycharis, S. (2016). Inquiry based-computational experiment, acquisition of threshold concepts and argumentation in science and mathematics education. *Educational Technology & Society*, *19*(3), 282-293.

Raes, A., & Schellens, T. (2015). Unraveling the motivational effects and challenges of web-based collaborative inquiry learning across different groups of learners. *Educational Technology Research & Development*, *63*(3), 405-430. https://doi.org/10.1007/s11423-015-9381-x

Rannikmäe, M. (2016). Some crucial areas in science education research corresponding to the needs of the contemporary society. *Journal of Baltic Science Education, 15*(1), 4-6.

Rhodes, S., Booth, J. N., Campbell, L. E., Blythe, R., Delibegovic, M. & Wheate, N. (2012). *The role of executive functions in science learning: Chemistry and cognition.* British Psychological Society, Developmental Section Conference Abstracts.

Rhodes, S. M., Booth, J. N., Campbell, L. E., Blythe, R. A., Wheate, N. J., & Delibegovic, M. (2014). Evidence for a role of executive functions in learning biology. *Infant & Child Development*, *23*(1), 67-83. https://doi.org/10.1002/icd.1823

Richardson, J. W., Imig, S., & Flora, K. (2014). Evaluating school leadership development through an international experience. *International Journal of Leadership in Education*, *17*(3), 353-369. https://doi.org/10.1080/13603124.2013.817611

Rihtaršič, D., Avsec, S., & Kocijancic, S. (2016). Experiential learning of electronics subject matter in middle school robotics courses. *International Journal ofTechnology & Design Education*, *26*(2) 205-224. https://doi.org/10.1007/s10798-015-9310-7.

Roland, B., & Martin, H. (2015). Impact of expert teaching quality on novice academic performance in the jigsaw cooperative learning method. *International Journal of Science Education*, *37*(2), 294-320. https://doi.org/10.1080/09500693.2014.985757

Romero, C., Master, A., Paunesku, D., Dweck, C. S., & Gross, J. J. (2014). Academic and emotional functioning in middle school: The role of implicit theories. *Emotion*, *14*(2), 227-234. https://doi.org/10.1037/a0035490

Roscoe, R. D. (2014). Self-monitoring and knowledge building in learning by teaching. *Instructional Science*, *42*, 327-351. https://doi.org/10.1007/s11251-013-9283-4

Ross, K., Hooten, M. A., & Cohen, G. (2013). Promoting science literacy through an interdisciplinary approach. *Bioscene: Journal of College Biology Teaching*, *39*(1), 21-26.

Rukavina, S., Zuvic-Butorac, M., Ledic, J., Milotic, B., & Jurdana-Sepic, R. (2012). Developing positive attitude toward science and mathematics through motivational classroom experiences. *Science Education International*, *23*(1), 6-19.

Sagirli, M. (2016). Analysis of reading comprehension levels of fifth grade students who learned to read and write with the Sentence Method. *Journal of Education and Training Studies*, *4*(2), 105-112.

Şahin, A. (2015). The effects of quantity and quality of teachers' probing and guiding questions on student performance. *Sakarya University Journal of Science*, *19*(1), 95-113. https://doi.org/10.19126/suje.06688

St. Clair-Thompson, H., Overton, T., & Bugler, M. (2012). Mental capacity and working memory in chemistry: Algorithmic versus open-ended problem solving. *Chemistry Education Research and Practice, 13*(4), 484-489. https://doi.org/10.1039/C2RP20084H

Sarma, G. P. (2015). The art of memory and the growth of the scientific method. *Interdisciplinary Description of Complex Systems*, *13*(3), 373-396. https://doi.org/10.7906/indecs.13.3.4

Sarma, M. S. R. (2015). Reflective practice and professional development at elementary teacher education level. *CLEAR International Journal of Research in Commerce & Management*, *6*(2), 6-8.

Sato, M., Bartiromo, M., & Elko, S. (2016). Investigating your school's science teaching and learning culture. *Phi Delta Kappan, 97*(6), 42-47. https://doi.org/10.1177/0031721716636872

Schickedanz, J. A., & Collins, M. F. (2013). *Teachers' responses to preschoolers' story misunderstandings: Moving beyond simple corrections.* Paper presented at the annual meeting of the Literacy Research Association, Dallas, TX.

Scogin, S. C., Kruger, C. J., Jekkals, R. E., & Steinfeldt, C. (2017). Learning by experience in a standardized testing culture: Investigation of a middle school experiential learning program. *Journal of Experiential Education, 40*(1), 39-57. https://doi.org/10.1177/1053825916685737

Shaffer, L., & Thomas-Brown, K. (2015). Enhancing teacher competency through co-teaching and embedded professional development. *Journal of Education and Training Studies*, *3*(3), 117-125. https://doi.org/10.11114/jets.v3i3.685

Shaha, S. H., & Ellsworth, H. (2013). Predictors of success for professional development: Linking student achievement to school and educator successes through on-demand, online professional learning. *Journal of Instructional Psychology*, *40*(1-4), 19-26.

Shahzad, K., & Naureen, S. (2017). Impact of teacher self-efficacy on secondary school students' academic achievement. *Journal of Education & Educational Development*, *4*(1), 48-72. https://doi.org/10.22555/joeed.v4i1.1050

Smart, J. B., & Marshall, J. C. (2013). Interactions between classroom discourse, teacher questioning, and student cognitive engagement in middle school science. *Journal of Science Teacher Education, 24*(2), 249-267. https://doi.org/10.1007/s10972-012-9297-9

Smith, T. (2016). Thinking science Australia: A short history of how thirty science lessons transform learning and teaching. *Teaching Science: The Journal of the Australian Science Teachers Association*, *62*(3), 16-21.

Snead, D. (2016). Middle school teachers' perceptions regarding the motivation and effectiveness of homework. *Journal of Inquiry and Action in Education*, *7*(2), 62-80.

Sornson, B. (2015). The effects of using the essential skills inventory on teacher perception of high-quality classroom instruction. *Preventing School Failure*, *59*(3), 161-167. https://doi.org/10.1080/1045988X.2014.886551

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

Steeg, S. M., & Lambson, D. (2015). Collaborative professional development: One school's story. *The Reading Teacher*, 68 (6), 473-478. https://doi.org/10.1002/trtr.1338

Stevenson, C. E. (2012). *Puzzling with potential: Dynamic testing of analogical reasoning.* (Unpublished doctoral dissertation). Leiden University, Leiden, Netherlands.

Stevenson, C. E., Bergwerff, C. E., Heiser, W. J., & Resing, W. M. (2014). Working memory and dynamic measures of analogical reasoning as predictors of children's math and reading achievement. *Infant & Child Development*, *23*(1), 51-66. https://doi.org/10.1002/icd.1833

Stewart, C. (2014). Transforming professional development to professional learning. *Journal of Adult Education*, *43*(1), 28-33.

Stoll, L. (2015). Three greats for a self-improving school system: Pedagogy, professional development and leadership. *Teaching Schools R&D Network National Themes Project 2012-14*.

Storksdieck, M. (2016). Critical information literacy as core skill for lifelong STEM learning in the 21st century: reflections on the desirability and feasibility for widespread science media education. *Cultural Studies of Science Education*, *11*(1), 167-182. https://doi.org/10.1007/s11422-015-9714-4

Sumsion, J., Lunn Brownlee, J., Ryan, S., Walsh, K., Farrell, A., Irvine, S., . . . & Berthelsen, D. (2015). Evaluative decision-making for high-quality professional development: cultivating an evaluative stance. *Professional Development in Education*, *41*(2), 419-432. https://doi.org/10.1080/19415257.2014.989257

Sun, J C-Y., Martinez, B., & Seli, H. (2014). Just-in-time or plenty-of-time teaching? Different electronic feedback devices and their effect on student engagement. *Journal of Educational Technology & Society*, *17*(2), 234-244.

Suvannatsiri, R., Santichaianant, K., & Murphy, E. (2015). Learning by teaching: Undergraduate engineering students improving a community's response capability to an early warning system. *European Journal of Engineering Education*, *40*(1), 95-113. http://dx.doi.org/10.1080/03043797.2014.928671

Target county school district board meeting notes. (2015, August 3).

Target county school district board meeting notes. (2016, August 4).

Target county school district board meeting notes. (2017).

Tas, Y., Sungur-Vural, S., & Öztekin, C. (2014). A study of science teachers' homework practices. *Research in Education*, *91*(1), 45-64. https://doi.org/10.7227/RIE.91.1.5.

Teale, W. H., Hoffman, J., & Paciga, K. (2013). What do children need to succeed in early literacy - and beyond? In K. Goodman, R. Calfee, & Y. Goodman (Eds.), *Whose knowledge counts in government literacy policies? Why expertise matters.* New York, NY: Routledge.

Tedman, D. K. (2005). Science teachers' views on science, technology and society issues. In S. Alagumalai et al. (Eds.), *Applied Rasch Measurement: A book of exemplars*, (pp. 227-249). Dordrecht: Springer. https://doi.org/10.1007/1-4020-3076-2_13

Teo, T. W., & Ke, K. J. (2014). Challenges in STEM teaching: Implication for preservice and inservice teacher education program. *Theory into Practice, 53*(1), 18-24. https://doi.org/10.1080/00405841.2014.862116

Terrazas-Arellanes, F. E., Knox, C., Strycker, L. A., & Walden, E. (2016).A face-to-face professional development model to enhance teaching of online research strategies. *Journal of Information Technology Education*, *15*, 335-376. https://doi.org/10.28945/3536

Tetnowski, J. (2015). Qualitative case study research design. *Perspectives on Fluency and Fluency Disorders*, *25*, 39-45. https://doi.org/10.1044/ffd25.1.39

Thien, L., & Razak, N. (2013). Academic coping, friendship quality, and student engagement associated with student quality of school life: A partial least square analysis. *Social Indicators Research*, *112*(3), 679-708. https://doi.org/10.1007/s11205-012-0077-x

Timur, B. (2012). Determination of factors affecting preschool teacher candidates' attitudes toward science teaching. *Educational Sciences: Theory and Practice*, *12*(4), 2997-3009.

Tondeur, J., Forkosh-Baruch, A., Prestridge, S., Albion, P., & Edirisinghe, S. (2016). Responding to challenges in teacher professional development for ICT integration in education. *Educational Technology & Society*, *19*(3), 110

Tran, V. T., Porcher, R., Tran, V. C., & Ravaud, P. (2017). Predicting data saturation in qualitative surveys with mathematical models from ecological research. *Journal of clinical epidemiology*, *82*, 71-78.

Trees, A. R., & Jackson, M. H. (2013). The learning environment in clicker classrooms: Student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media and Technology*, *40*(8), 64-71. Retrieved from https://scholar.google.com/

Tunca, N. T. (2015). The regression level of constructivist learning environment characteristics on classroom environment characteristics supporting critical thinking. *Eurasian Journal of Educational Research (EJER)*, (60), 181-200. https://doi.org/10.14689/ejer.2015.60.11

Ulanoff, S. H., Quiocho, A. M. L., & Riedell, K. (2015). The use of questioning in inquiry-based lessons with bilingual learners: Developing academic language and discourse. *Curriculum and Teaching Dialogue*, *17*(1-2), 35-56.

United States Department of Education. (2010). Fast facts. *National Assessment of Educational Progress*. Retrieved from http://nces.ed.gov/fastfacts/

Uslu, Ö. (2017). Evaluating the professional development program aimed technology integration at the era of curriculum change. *Educational Sciences: Theory & Practice, 17*(6), 2031-2055. https://doi.org/10.12738/estp.2017.6.0116

Uzuntiryaki-Kondakçi, E., & Çapa-Aydin, Y. (2013). Predicting critical thinking skills of university students through metacognitive self-regulation skills and chemistry self-efficacy. *Educational Sciences: Theory & Practice*, *13*(1), 666-670.

Valdmann, A. A., Holbrook, J., & Rannikmae, M. (2017). Determining the effectiveness of a design–based, continuous professional development program for science teachers. *Journal of Baltic Science Education, 16*(4), 576-591.

van Aalderen-Smeets, S. I., & Walma van der Molen, J. H. (2015). Improving primary teachers' attitudes toward science by attitude-focused professional development. *Journal of Research in Science Teaching*, *52*(5), 710-734. https://doi.org/10.1002/tea.21218

van Loon, A. M., Ros, A., & Martens, R. (2012). Motivated learning with digital learning tasks: What about autonomy and structure? *Educational Technology Research and Development, 60*(6), 1015-1032. https://doi.org/10.1007/s11423-012-9267-0

Wallace, C. S., & Brooks, L. (2015). Learning to teach elementary science in an experiential, informal context: culture, learning, and identity. *Science Education*, *99*(1), 174-198. https://doi.org/10.1002/sce.21138

Wang, A., Chai, C. S., & Hairon, S. (2017). Exploring the impact of teacher experience on questioning techniques in a Knowledge Building classroom. *Journal of Computers in Education*, *4*(1), 27-42. https://doi.org/10.1007/s40692-016-0057-2

Wang, S., Hsu, H., Campbell, T., Coster, D., & Longhurst, M. (2014). An investigation of middle school science teachers and students use of technology inside and outside of classrooms: Considering whether digital natives are more technology savvy than their teachers. *Educational Technology Research & Development*, *62*(6), 637-662. https://doi.org/10.1007/s11423-014-9355-4

Watt, S. J., Therrien, W. J., & Kaldenberg, E. (2013). Promoting inclusive practices in inquiry-based science classrooms. *Teaching Exceptional Children*, *45*(4), 40-48. https://doi.org/10.1177/004005991304500405

Watters, J. J., & Diezmann, C. M. (2013). Community partnerships for fostering student interest and engagement in STEM. *Journal of STEM Education: Innovations and Research*, *14*(2), 47-55.

Welch, F. C., Pitts, R. E., Tenini, K. J., Kuenlen, M. G., & Wood, S. G. (2010). Significant issues in defining and assessing teacher dispositions. *The Teacher Educator*, *45*(3), 179-201. https://doi.org/10.1080/08878730.2010.489992

White, J., Drew, S., & Hay, T. (2009). Ethnography versus case study: Positioning research and researchers. *Qualitative Research Journal, 9*(1), 18-27. https://doi.org/10.3316/QRJ0901018

White, S., & Kline, J. (2012). Developing a rural teacher education curriculum package. *Rural Educator*, *33*(2), 36-43.

Whitworth, B. A., & Chiu, J. L. (2015). Professional development and teacher change: The missing leadership link. *Journal of Science Teacher Education*, *26*(2), 121-137. https://doi.org/10.1007/s10972-014-9411-2

Williford, A. P., Carter, L. M., Maier, M. F., Hamre, B. K., Cash, A., Pianta, R. C., & Downer, J. T. (2017). Teacher engagement in core components of an effective, early childhood professional development course: Links to changes in teacher–child interactions. *Journal of Early Childhood Teacher Education*, *38*(1), 102-118. https://doi.org/10.1080/10901027.2016.1269028

Willis, J. W. (2007). *Foundations of qualitative research: Interpretive and critical approaches*. Thousand Oaks, CA: Sage.

Wood, C. L., Goodnight, C. I., Bethune, K. S., Preston, A. I., & Cleaver, S. L. (2016). Role of professional development and multi-level coaching in promoting evidence-based practice in education. *Learning Disabilities: A Contemporary Journal*, *14*(2), 159-170.

Wood, J., Thall, T., & Parnell, E. C. (2015). The move: Reggio Emilia-inspired teaching. *Complicity: An International Journal of Complexity and Education*, *12*(1), 98-108. Retrieved from https://scholar.google.com/

Wu, P. L., Wu, L. C., Shih, W. L., & Wu, M. L. (2014). A comparison study on the influence of implementing inquiry-based instruction on science learning motivation and interest. *Asian Journal of Management Sciences & Education* 3(3), 75-82.

Wu, Y. C., Mar, L., & Jiau, H. C. (2013). A service-based program evaluation platform for enhancing student engagement in assignments. *Journal of Educational Technology & Society*, *16*(4), 122-132.

Wyatt, M. (2016). Are they becoming more reflective and/or efficacious? A conceptual model mapping how teachers' self-efficacy beliefs might grow. *Educational Review*, *68*(1), 114-137. https://doi.org/10.1080/00131911.2015.1058754

Xia, J., Caulfield, C., & Ferns, S. (2015). Work-integrated learning: Linking research and teaching for a win-win situation. *Studies in Higher Education*, *40*(9), 1560-1572. https://doi.org/10.1080/03075079.2014.882302

Xie, Q., & Andrews, S. (2013). Do test design and uses influence test preparation? Testing a model of washback with structural equation modeling. *Language Testing*, *30*(1), 49-70. https://doi.org/10.1177/0265532212442634

Xie, Y., & Killewald. A. (2012). *Is American science in decline?* Cambridge, MA: Harvard University Press.

Yeung, S. S. (2015). Conception of teaching higher order thinking: perspectives of Chinese teachers in Hong Kong. *Curriculum Journal*, *26*(4), 553-578. https://doi.org/10.1080/09585176.2015.1053818.

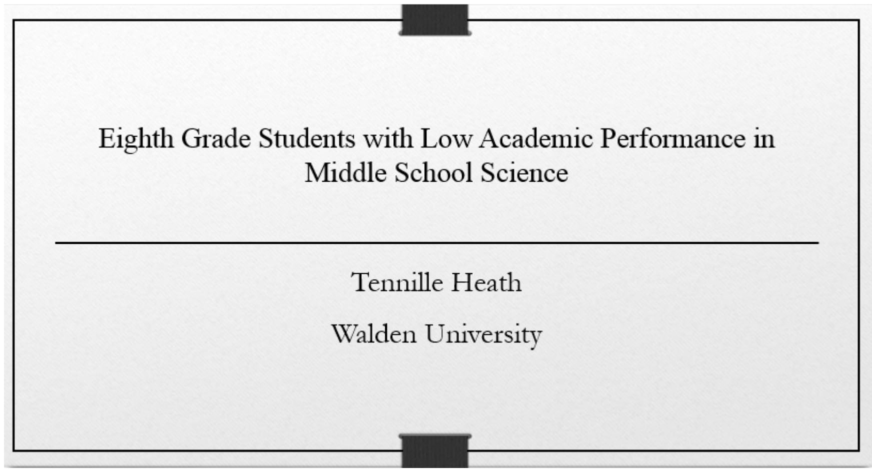
Yin, R. (2009). *Case study research: Design and methods* (4th ed.). Los Angeles, California: SAGE Publications.Yin, R. K. (2003). *Application of case study research* (2nd ed.). New Delhi: Sage Publications.

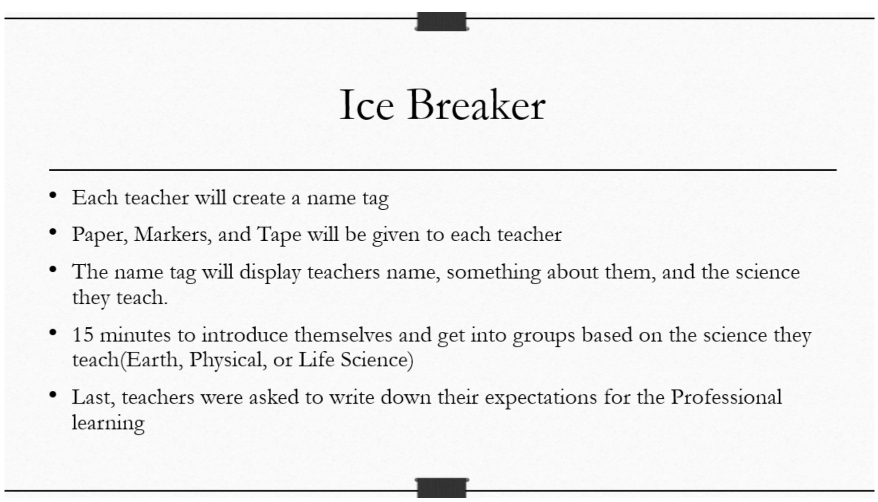
Yin, R. K. (2004). *The case study anthology*. Thousand Oaks, CA: Sage.

Yopp, R. H., & Yopp, H. K. (2012). Young children's limited and narrow exposure to informational text. *The Reading Teacher*, *65*(7), 480-490. https://doi.org/10.1002/TRTR.01072

Yüksel, M., & Geban, Ö. (2016). Examination of science and math course achievements of vocational high school students in the scope of self-efficacy and anxiety. *Journal of Education and Training Studies*, *4*(1), 88-100.

Appendix A: The Project





Objectives of 3 Day Professional Development

- Approaches and Beliefs to Student Motivation, Engagement, and Achievement
- Authentic Instruction
- Interactive Homework
- Inquiry Based Instruction
- Argumentation
- Higher Order Questioning

Day 1: Approaches and Beliefs to Student Engagement, and Achievement

- Discuss in your groups some of the approaches and beliefs to student engagement and achievement.
- Watch a U-Tube Video on student Engagement and Achievement. https://www.youtube.com/watch?v=nPHtNkdFFAE
- Discuss thoughts about the video ☺

Authentic Instruction

- Problem: How can teachers enhance student motivation?
- Authentic Instruction: Herrington, et al. (2014) define authentic instruction as the combination of evaluation and instruction designed to enhance the achievement of students through lessons taught at elevated intellectual levels and which comprise skills and information whose value goes beyond school. Inauthentic techniques are on the other hand considered to comprise lower level skills, for instance memorization, regurgitation, or solving problems which have no real life applications (Nie, et al., 2013). The shift to authentic instruction therefore involves a move towards high order teaching and learning (Chee, et al., 2015).

How can I use Authentic Instruction in my class?

- Watch the video, discuss and take the quiz☺
- http://study.com/academy/lesson/authentic-learning-activities-examples-lesson-quiz.html

Example of Authentic Instruction

- Discuss with your group an instance when you asked your students to depict causes and effects in science experiments, come up with conclusions as it regards to what happened, predict different ways through which the problem can be solved and argue for the best technique.
- 2 People from each group will discuss their responses

Why students aren't motivated to do Homework? ☹

- Interactive Homework: Interactive assignments are designed in a manner that parents with no education can still provide answers to the questions asked with the focus being on what the students are intended to learn and not on the knowledge of the parent.
- Individually: 10 minutes to reflect on an interactive homework assignment given to your students

Examples of Interactive Homework

- Teachers Involve Parents in Schoolwork (TIPS) enables the students to interact with their family partners concerning the skills that they learned in their classroom and to apply the concept in the real world (Ariës and Cabus, 2015)
- The use of interactive homework stems from their way of promoting hands-on experience and discovery in a manner that makes the study of science to be of relevance and interest (Gonida and Cortina, 2014)

Big Ideas that Solve Problems☺

- In groups answer the questions: How can we motivate students to learn science? How do we motivate students to complete homework.
- Each group will be given big chart paper. They will respond to the questions, after they have collaboratively discussed everything that has been presented.
- This activity concludes professional learning for DAY 1

Day 2: Evaluation

- Each group will select two people to present their responses to the questions from Day 1. How can we motivate students to learn science? How do we motivate students to complete homework.
- Next, teachers will discuss their experiences with using the instructional strategies from Day 1. Authentic Instruction, and Interactive Homework.

Why do students struggle with Inquiry Based Instruction?

- Teachers will complete a KWL chart

K What do you know about Inquiry Based Instruction?	W What do you want to know about Inquiry Based Instruction?	L What did you learn about Inquiry Based Instruction?

Inquiry Based Instruction

- IBI is also defined as a multidimensional activity which involves observing, questioning and examining books as well as other materials; investigating and reviewing the experimental evidence and communicating predictions (Abdi, 2014). Such instructional strategies include hands-on activities and student investigations which help in the development of positive attitudes and enable the sustaining of student motivations.

Watch and Learn
Inquiry Based Instruction

- https://www.youtube.com/watch?v=37oG1p4uR0A
- Discuss in groups ways that Inquiry Based Instruction can be used in your classroom
- Teachers will use iPADs to further investigate the use of Inquiry Based Instruction
- Each group will demonstrate the use Inquiry Based Instruction in the classroom

Reflection

- Teachers will write a lesson plan that will incorporate the use of inquiry based instruction.
- Complete the “L” in the KWL chart now that you have an understanding of Inquiry Based Instruction

Day 3: What is Argumentation?

- Argumentation is described as the process through which an argument is formalized and students are encouraged to give consideration to evidence in their presentation and defense of decisions in a manner that is logical and persuasive (Carson and Dawson, 2016)
- This takes place when students use scientific language and knowledge in an original way in their arguments, leading to the reinforcement of their conceptual understanding (Osborne, et al., 2013).

How can teachers use Argumentation in the classroom?

- https://www.youtube.com/watch?v=HqdUkmZDqj0
- Discuss in your groups how you can implement Argumentation in your class

Name this strategy!

- The strategy will be written on the Board with Missing letters. Teachers will be given 10 seconds to figure out the strategy
- First person to give the answer will be rewarded ☺
- Higher Order Questioning ☺

What is Higher Order Questioning?

- Watch the video, and discuss your thoughts with your group
- https://www.teachingchannel.org/videos/teaching-higher-order-thinking-skills

Higher Order Questioning Displayed ☺

- Each group will display how they will use higher order questioning in their class.
- Teachers will be given asked to rate the professional development 1-10. Next, they will reflect on what they have learned and what can be done to improve the professional development

Appendix B: Open-Ended Interview Questions

1. What are your perceptions of students' attitudes toward learning science and the district's curriculum guide?
2. What challenges do you perceive are related to teaching science, and how can students make a personal connection to the science concepts taught?
3. What developmental and operational learning characteristics do you perceive are relevant for science learning education?
4. How do you perceive that current educational strategies and curriculum include opportunities for the inclusion of developmental and operational characteristics of the learners in science education?
5. What recommendations, if any, would you make to increase the inclusion of developmental and operational characteristics of the learner in science education.

Appendix C: Bracketing Template

Study Problem and Purpose	Research Questions	Data Collection Tools	Datapoints Yielded	Data Source
Peach Middle School and Pear Middle School recorded low scores in 2012-2013 through 2016-2017 on the Science CRCT and GA's Milestones Assessments.	**RQ 1:** What are teachers' perceptions of challenges of teaching science to eighth-grade students and how their students relate what they have learned to the world around them?	Interview and Document protocol	Interview Questions 1-2 1.What are your perceptions of students' attitudes toward learning science and the district's curriculum guide? 2.What challenges do you perceive are related to teaching science, and how can students make a personal connection to the science concepts taught? Targeted County Curriculum Guide	Participants provided data through interviews. Other data were collected through document review.
	RQ 2: What developmental and operational learning characteristics are viewed by science teachers as affecting the achievement of proficiency in science learning?	Interview and Document protocol	Interview Questions 3-5 3. What developmental and operational learning characteristics do you perceive are relevant for science learning education? 4. How do you perceive that current educational strategies and curriculum include opportunities for the inclusion of developmental and operational characteristics of the learners in science education? 5. What recommendations, if any, would you make to increase the inclusion of developmental and operational characteristics of the learner in science education.	Participants provided data through interviews. Other data were collected through document review.

Appendix D: Reaction Evaluation

How is the professional development training significant to your content area?

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How did the delivery method help you understand the professional development training? Give an alternate method of delivery that you prefer and why?

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State whether or not the materials used for professional development helped to increase your engagement. If you did not benefit from materials used, suggest other materials that may help you be more engaged? i.e. promethean boards, handouts, markers, chart paper.

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How do you feel about the time allocated for the professional development training?

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How are the problems given during the discussions sessions relevant to the situations in the classrooms?

Please give any additional feedback regarding the professional development training.

Learning Evaluation

Give a summary of what you learned from the professional development training. How did you implement the strategies taught in your classroom?

Behavior Change Evaluation

How has the application of the new teaching strategy had an impact on timeliness of homework delivery, completeness, and accuracy levels?

How have your students increased their higher order thinking skills? Provide feedback on students' ability to present correct and well-supported arguments.

Results

Reflect on whether or not the professional development training has met its four objectives.

How did the professional development training help teachers understand the link between motivation and instructional strategies that take into account the developmental and the operational level of students?

How did the professional development training help teachers develop a theoretical understanding of the new instructional strategies as the solution to the current deficiencies?

How did the professional development training develop teachers' confidence in the application of the new instructional strategies?

How did the professional development training provide monitoring and support in order to achieve student improvement in standardized test scores?