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High School Science Teachers' Perspectives on Their Technology Knowledge, Content, and Pedagogy

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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,
and that any and all revisions required by
the review committee have been made.

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Abstract

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MEd, Florida A & M University, 2001

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Doctoral StudySubmitted in Partial Fulfillment

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Abstract

In a southeastern U.S. school district, it was unknown how teachers integrated technology into their classroom teaching in the science, technology, engineering, and mathematics (STEM) curriculum. Teachers should be knowledgeable of their content, pedagogy of the content, and delivery instruction to improve students' learning outcomes. The purpose of this bounded qualitative case study was to examine how teachers integrated technology into their teaching to improve science students' learning outcomes. Mishra and Koehler's and Shulman's theories of technology, pedagogy, and content knowledge served as the conceptual framework. Purposeful sampling was used to select 12 certified science teachers, with at least 1 year of teaching experience, who had access to instructional technologies and taught STEM-related content. Data were collected through teachers' lesson plans and semistructured interviews. Typological analysis was used to code and summarize data into emerging themes. Teachers used computers, projectors, and mobile computer carts as instructional tools and sources to help students learn. Additionally, poor Internet connection, lack of access to district web-based science sites, interactive Smart boards, and digital projectors, and obsolete and slow-running computers were barriers to teaching and learning. Based on the findings, a 3-day professional development project was developed to improve teachers' knowledge and technology use in the STEM curriculum. This endeavor may contribute to positive social change when district administrators provide STEM teachers with technology tools and training to improve science instruction and optimal learning outcomes for students.

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Dedication

This dissertation is dedicated to my Heavenly Father, the God, Lord Almighty, who is my keeper and the source of my enduring strength; my mother, Mrs. Cecilia; my dad, Chief Raymond; my wife, Mrs. Blessing; and my children, Faith Mentor, Sophy Mentor, Glory Mentor, Stephanie Mentor, Mentor Mentor III, and Micaela Mentor, in spite of their father spending so much time away from them working tirelessly on this dissertation.

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Special thanks to Dr. Christopher Cale, my committee chairperson, for his dedication to success and hard work, and for providing me unwavering guidance throughout this doctoral journey. Dr. Christopher Cale, I sincerely appreciate you for helping me to accomplish my goals in this doctoral journey. Special thanks to Dr. David Falvo, my second committee member, for his dedication to success and hard work, and for providing me unwavering guidance throughout this doctoral journey. Special thanks to Dr. Mary Howe, my URR, for her support and guidance throughout my doctoral journey.

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Section 1: The Problem

The Local Problem

For several years, school districts across the United States have relied on technology to drive classroom instruction in science courses to improve student learning outcomes (Reiss & Millar, 2014; Xie & Reider, 2014). Districts, teachers, and students benefit the most from technology when teachers are effectively integrating and using technology to facilitate classroom instruction (Acikalin, 2014; Bang & Luft, 2013; Fozdar, 2015; Hur, Shannon, & Wolf, 2016; Kintu & Zhu, 2016). Across the United States, science teachers are expected to use educational technology to deliver effective pedagogical instruction in science classrooms (National Science Teachers Association [NSTA], 2015). Despite this expectation, many science teachers remain uncertain about how to integrate technology in their classroom teaching in a manner consistent with NSTA's science reform practices (NSTA, 2015). According to the NSTA, effectively integrating technology into science classrooms helps to support student learning in schools.

The challenges confronting teachers seeking to integrate technology into science classrooms have been found to be associated with various factors (Carver, 2016). One of the key factors is how teachers integrate technology into science classroom instruction to improve student learning outcomes (Carver, 2016; DePountis, Pogrund, Griffin-Shirley, & Lan, 2015; Eristi & Dindar, 2012; Rehmat & Bailey, 2014; Sparapani & Calahan, 2015). Other factors associated with teachers' challenges in integrating technology into the classroom include teachers' confidence in technology use and the time devoted to technology instruction in the classroom. Adequate research is lacking regarding how teachers can effectively use educational technology tools for classroom instruction to improve student-centered learning, engagement, performance, task accomplishment, and achievement in science (DePountis et al., 2015; Dolenc & Abersek, 2015; Schmidt & Fulton, 2016). Further research studies may help school administrators to recommend strategies that will enable teachers to facilitate technology integration into the curriculum to improve students' learning outcomes.

Definition of the Problem

There are challenges to technology integration in science education that can hinder the effectiveness of this effort (Gibson, 2013; Gofron, 2014). The general problem associated with technology integration impedes teachers' delivery of effective instruction in science classrooms. At the project study site, a gap in practice exists in that it is unknown how teachers integrate technology into their classroom teaching to improve students' learning in science. Science teachers require assistance in using technology to facilitate instruction in science classrooms. In an internal data report on the 2013-2015 technology integration plan in the study district, district leadership revealed that teachers in the science department did not integrate technology into their classroom teaching based on the professional development (PD) learning provided to them on the appropriate use of technology to aid students' learning outcomes in science education.

According to the internal report mentioned above, district leadership invested $13,456,379 in 2016 on technology integration with the goal of improving student learning outcomes in all subject areas, including science. This urban high school acquired new software and hardware to support teachers' technology integration efforts to facilitate classroom instruction. The technological investment by this southeastern U.S. school district was an initiative supported by the International Society for Technology in Education (ISTE, 2016). According to ISTE, technology use alone does not adequately enhance students' academic skills; rather, the technological skills that students acquired in classrooms can enable them to coordinate research investigations and learning activities in science. Sun, Chee-Kit, and Wenting (2014) reported that teachers played a vital role in integrating technology to facilitate science instruction. Xie and Reider (2014) posited that school districts should increase their support for teachers to enable them to integrate technology successfully to enhance teaching and learning outcomes in science.

According to the project study district's 2013-2015 technology integration plan, the technological investment to increase teachers' classroom instructional delivery in the science department at the project study site was unsuccessful. The leadership team at the project study site observed that teachers' difficulty in making academic gains with technology in science could be attributed to various factors, including how teachers integrated technology into their classroom teaching to improve students' learning outcomes in science. Despite district efforts to increase student learning using technology in science courses, student test scores on the science portion of the Georgia High School Graduation Test (GHSGT) remained low, according to the district's 2013-2015 technology integration plan, indicating the existence of a possible problem at the local level. According to the Georgia Department of Education (GDE) Accountability Division, 85.4% of 12th grade students in southeastern U.S. school district scored below

500 points, which is the score required to pass the science portion of the GHSGT (GDE, 2014, 2015).

The specific local problem and professional practice gap addressed in this bounded qualitative case study were that it was unknown how teachers at the project study site implemented technology and described their technology, pedagogy, and STEM content knowledge to improve students' learning outcomes in science. Dimirel and Aslan (2014) asserted that effective integration of technology in the science curriculum improved student-centered learning, engagement, performance, and task accomplishment, which ultimately increased student achievement. Wang, Hsu, Campbell, Coster, and Longhurst (2014) concurred and argued that sustaining technology integration in science depends on teacher application of technology tools in the classroom environment. The 21st-century learner needs to develop problem-solving and critical thinking skills to function in a technology-integrated science classroom (Flogie & Abersek, 2015; Ramma, Samy, & Gopee, 2015). Other researchers (Al Musawi, Ambusaidi, Al-Balushi, & Al-Balushi, 2015; Bilek, 2016; Campbell & Rivas, 2012; Fozdar, 2015; Shien & Tsai, 2015) have called for further investigation in the area of technology integration to enhance students' learning outcomes in science.

In this study, I sought to obtain an understanding of how teachers at the project study site integrated technology into their teaching to improve student learning outcomes in science classrooms. Such knowledge should be an asset for school administrators to understand teachers' perspectives on the challenges to technology integration in the science classroom setting at the project study site.

Rationale

Evidence of the Problem at the Local Level

Many scholars have reinforced the need to integrate technology for effective teaching and learning (Schrum & Levin, 2016). The study district had not been successful in achieving technology integration benefits in the science department at the project study site. A need existed to further investigate this gap in instructional delivery with technology.

According to data from the GDE's Accountability Division, 85.4% of 12th-grade students in the science department at the project study site scored below 500 points, which is the passing score required for the science portion of the GHSGT (GDE, 2014, 2015, 2016). When students' test grades in science were compared to their performance in other subject areas at the project study site, 81.2% of students' test grades remained low in science (GDE, 2016). Further, data from GDE's Accountability Division indicated that in a climate survey conducted by school administrators at the study site, 95.5% of teachers expressed the belief that students were not learning relevant science content materials necessary to pass science.

According to an internal data report from the 2013-2015 technology integration plan, teachers in the science department did not understand how to integrate technology in their classroom teaching based on the PD learning provided to them on the appropriate use of technology to aid students' learning in science education. Despite the purchase of new computer software and the provision of professional learning for teachers to increase students' learning in science, students' test scores in science remained low. More effective technology integration in science instruction and projects to improve students' learning outcomes in the science department may help teachers in increasing student-centered learning, engagement, performance, task accomplishment, and achievement levels. Research literature reviewed for this study supported the notion that effective technology integration in science instruction improves students' learning outcomes.

Several prominent science and technology researchers have examined issues related to technology integration in science. Researchers have found that effective technology integration in science instruction and projects improves students' learning outcomes (Baser, Ozden, & Karaarslan, 2017; Doleric & Abersek, 2015; Laine, Nygren, Dirin, & Suk, 2016; Potter, Ernst, & Glennie, 2017; Pringle, Dawson, & Ritzhaupt, 2015). Moreover, the above-mentioned researchers asserted that it is critical for teachers to integrate technology into their classroom teaching practices in district schools across the United States. Based on the research literature reviewed, it is important to conduct further investigations on teachers' use of technology in district schools across the United States. This recommendation for further investigation was instrumental in researching the problem with science teachers at the local site.

Evidence of the Problem From the Professional Literature

As part of the Every Student Succeeds Act (ESSA), U.S. teachers were required to integrate technology into their curricula to enhance students' learning and close achievement gaps in science (Wang, Hsu, Campbell, Coster, & Longhurst, 2014). Years after the passage of ESSA, teachers in the United States have not made adequate progress to integrate technology into the science curriculum. Bang and Luft (2013) argued that there is uncertainty among teachers on how to integrate technology in the science curriculum.

Affirming the scarcity of research studies in technology integration, Schmidt and Fulton (2016) attested that few research studies had reported on teachers' overall progress toward effective technology integration. Sparapani and Callahan (2015) maintained that achievement gaps tend to widen when adequate supports are not given to low-performing students in science with technology. In addition, Rehmat and Bailey (2014) posited that despite the increased availability of technology for instruction in classrooms, it is unknown how teachers integrated technology in their classroom teaching to improve students' learning outcomes in science. Reiss and Millar (2014) concurred and argued that for technology integration to be effective in classroom instruction, it is imperative for teachers to understand how to integrate technology into their science curriculum.

According to ISTE (2016), technology integration alone does not adequately enhance students' learning. The skills that students acquire through technology using simulations, games, videos, animations, and virtual laboratories instead help them in classroom activities and task accomplishment. ISTE has recommended strategies for technology integration to assist students in learning. ISTE has also recommended other methods of technology integration to assist teachers in facilitating classroom instruction effectively. The district in this study used ISTE strategies in order to bolster teachers' effective technology integration into classroom instruction. According to the technology coordinator in the southeastern U.S. school district, the teachers received professional learning on the appropriate use of technology to aid students' learning outcomes in science education. However, this resulted in negligible gain in students' academic growth. Due to the students' negligible academic gain in science with technology, it was unknown how teachers integrated technology into their classroom teaching to improve students' learning outcomes in science.

ISTE (2016) asserted that technology integration is an educational strategy to transform teaching and learning in the classroom to enhance students' learning outcomes. It was necessary to conduct a study to examine how high school teachers integrated technology in their classroom teaching to improve students' learning outcomes in science. This qualitative case study examined how STEM teachers integrated technology in their classroom teaching to improve students' learning outcomes in science using the strategies and recommendations of ISTE with other prominent science and technology researchers cited in the professional literature. The purpose of this bounded qualitative case study was to examine how teachers integrated technology in their classroom teaching to improve students' learning outcomes in science.

Definition of Terms

Active learning: Learning that focuses on student engagement and provides students the opportunity to inquire, explore, collaborate, and experience other forms of discovery (Bryant et al., 2013).

Adequate yearly progress (AYP): A measure to determine whether a public school or school district is meeting its required annual progress as established by the state (GDE, 2013).

Blended learning: An educational approach in which students learn in part through digital delivery and online media, and in which students control the pacing of learning overtime (Guler & Sahin, 2015).

Common Core Georgia Performance Standards (CCGPS): Guidelines regarding skills and knowledge that students in Georgia must master to succeed beyond high school in core content areas (GDE, 2013).

Georgia High School Graduation Test (GHSGT): A competency-based test administered in the spring semester of a student's 11^{th}-grade year to determine a student's proficiency in English language arts, mathematics, science, social studies, and writing (GDE, 2013).

Georgia Performance Standards (GPS): Expectations set by the GDE for instruction, assessment, and student work. The performance standards enable students to master the skills needed to solve a problem, reason, and communicate in order to make connections with other information (GDE, 2013).

International Society for Technology in Education (ISTE): A nonprofit organization that serves educators and education leaders who empower learners to succeed in a connected world. The organization serves over 100,000 education stakeholders throughout the world (ISTE, 2016).

National Science Teachers Association (NSTA): This national association for science teachers takes the position that computers should have a major role in the teaching and learning of science. Computers have become essential classroom tools for "the acquisition, analysis, presentation, and communication of data in ways that allow students to become active participants in research and learning" (NSTA, 2015, p. 2).

Professional development (PD): A specialized training and/or workshop intended to help teachers, administrators, and all educators to improve their professional knowledge and skills in the workplace (Murthy, Iyer, & Warriem, 2015).

Professional learning environment: Any collection of resources and content that students have chosen to use in directing their own learning at their own pace (Johnson, Adams, & Cummins, 2012).

Simulation: A process of developing a model that enables students to imitate the operation of real-world situations over time (Adams et al., 2012).

Serious gaming: Simulations of real-world events designed to assist students in problem solving during classroom instruction (Adams et al., 2012).

Science, technology, engineering, and mathematics (STEM): An educational program designed to prepare all students for college and graduate study. The main objective of STEM is to improve investigation and inquiries, logical reasoning, and collaboration skills among students (Yildirim & Sidekli, 2018).

Student-centered learning: An instructional approach driven primarily by students' needs rather than by teachers' directives (Bachtold, 2013).

Technology integration: The use of computer tools such as desktop computers, laptops, handheld computers, software, or Internet in K-12 schools for instructional purposes (Acikalin, 2014).

Technology, pedagogy, and content knowledge (TPACK): A conceptual framework that a teacher needs in order to understand how to implement effective pedagogical practice in a technology-enhanced learning environment (Koehler, Mishra, & Cain, 2013).

Significance of the Study

Through the investigation of this problem, the southeastern U.S. school district may receive data to use in decision making and policy formulation. Notably, this study could improve student learning outcomes in science by enabling decision makers and stakeholders to align policy and channel resources where needed. According to an internal data report from the southeastern school district's 2013-2015 technology integration plan, the U.S. Department of Education mandated that school districts invent a plan to enable teachers to become competent in technology integration to promote students' learning. Consequently, the significance of the problem for this study may directly influence students' learning outcomes.

Eristi, Kurt, and Dindar (2012) discussed the importance of teachers' technology use to facilitate classroom instruction. Eristi et al. reported on the relevance and importance of technology integration, asserting that it can shape the future of students' learning in society. Eristi et al. contended that districts should focus more on technological application to promote students' learning and educational growth.

Mitten, Jacobbe, and Jacobbe (2017) discussed how teachers should integrate technology in schools, addressing lesson resources, organization, effectiveness, collaboration with other teachers, and connections with parents. Lee (2017) concurred and asserted that some of the technology integration benefits for teachers in the classroom included lesson effectiveness and instructional collaboration among teachers. Therefore, the significance of this study rests in its potential to have a direct influence on teachers' technology integration in classroom instruction.

Research Question(s)

The purpose of this study was to examine how teachers integrated technology in their classroom teaching to improve students' learning outcomes in science. In alignment with the local problem and the purpose of this study, I developed two research questions that were critical to the "shaping and direction" of this qualitative case study (Merriam, 2009):

RQ1: How do high school science teachers at a southeastern school district implement technology in STEM classes?

RQ2: How do high school science teachers at a southeastern school district describe their technology, pedagogy, and STEM content knowledge?

Review of the Literature

In this section, I present a critical discussion of the literature related to technology integration in science curriculum in the United States. In this study, the purpose of the literature review was to identify and analyze research information pertaining to educators' integration of technology in their classroom teaching. The databases used to search the current literature pertaining to technology integration were ERIC, Education Research Complete, and Education for SAGE. The search terms used to find applicable articles were *technology, technology integration, technology use, information and* *communications technology (ICT) integration,* and *education technology.* Over 50 articles published within the past 5 years were reviewed in writing the literature review.

In this literature review, I begin with a discussion of the conceptual framework, which is followed by a review of literature related to the broader problem. The literature search encompassed sources addressing the use of technology integration for effective classroom instruction and technology integration in schools. I explored literature related to school leadership's role in technology integration, the effective implementation of technology integration in secondary science education, and the importance of effectively implementing technology in education. I complete the literature review with a discussion of technology integration and school policy making, barriers to effectively implementing technology integration in schools, and educational technology integration tools used in science, ending with a conclusion.

Conceptual Framework

In this project study, I used technology, pedagogy, and content knowledge (TPACK) as the conceptual framework. TPACK as a framework was advanced by Mishra and Koehler (2006) and builds on Shulman's (1986) theory concerning the need for teachers to draw on pedagogical content knowledge (PCK). Shulman's theory indicates that mere content knowledge may be pedagogically useless as a content teaching skill without the implementation of technology knowledge (p. 8). Teachers must have knowledge of their content, know how to teach the content, and know how to deliver instruction in the specific content areas they teach. According to Shulman, these are different types of knowledge needed by teachers for pedagogical classroom instruction. In further argument, Koehler and Mishra (2009) emphasized that teachers' technology knowledge must encompass ways of thinking about technology, working with technology tools, resources about technology use in our daily lives, and understanding when technology information is beneficial or not when working to achieving a goal.

The TPACK model by Lee and Kim (2014) was selected for this study because the framework's constructs align with the concepts in the problem. In this study, the TPACK framework constructs also served as a coding template for data analysis (Lee & Kim, 2014) to analyze how teachers used technology integration in their classroom teaching to improve students' learning outcomes. The TPACK framework guided data collection and analysis (Lee & Kim, 2014) to explain and confirm how teachers implemented technology integration in their classroom teaching. The three components of TPACK (technology knowledge, pedagogy knowledge, and content knowledge) assisted me in analyzing qualitative data to answer the research questions posed in this study.

The TPACK framework contained the typologies that I used to analyze the data. In a research study, Tondeur et al.(2012) argued that using key themes for content and instructional delivery methods is critical in preparing teachers to implement technology effectively in their classroom teaching in secondary education. Davies (2011) validated this notion, positing that content and delivery methods played a major role in the analysis of teachers' effective implementation of technology integration in their instruction. The use of themes associated with content and instructional delivery methods served as the initial themes for analyzing data, as well as a means to provide more detailed and accurate analysis. Ultimately, typological analysis provided the answers needed for the research questions posed in this study.

The TPACK model as a coding template. I used the TPACK model as a guide to analyze the approaches that teachers used to implement technology integration in their classroom teaching. Several researchers asserted that the TPACK model was effective in providing a framework to understand teachers' technology knowledge, pedagogical knowledge, and content knowledge needed for effectively implementing technology integration into their classroom teaching in science (Celik, Sahin, & Akturk, 2014; Cengiz, 2015; Harris, Grandgenett, & Hofer, 2012; Tomte, Enochsson, Buskqvist, & Karstein, 2015; Van Driel & Berry, 2012).

The TPACK model consists of three components: technology knowledge, pedagogical knowledge, and content knowledge (Tomte et al., 2015; Voogt, Fisser, Pareja Robin, Tondeur, & Van Braak, 2013). These three components in the TPACK model are critical for teachers to effectively implement technology integration in their classroom teaching using adequate instructional strategies because they enable teachers to facilitate effective classroom instruction and activities in science (Cavanagh & Koehler, 2013; Doering, Koseoglu, Scharber, Henrickson, & Lanegran, 2014; Koehler et al., 2013; Koh, Chai, & Lee, 2015; Pringle, Dawson, & Ritzhaupt, 2015).

In a research study by Cavanagh and Koehler (2013), the implementation of the TPACK model using a seven-criterion lens was used to measure the success and challenges of effectively implementing technology integration in the classroom setting. Teachers used a seven-criterion lens checklist based on the TPACK model to make important decisions in the classroom. The results supported reliable and valid measurements in TPACK. Cavanagh and Koehler found that positive measurement principles and techniques helped other researchers to ensure reliable and valid measurement in TPACK research.

The TPACK model can be used to support teachers in instructional methods and delivery of information to their students in the classroom setting (Khan, 2014). Koh (2013) argued that the success of using the TPACK model is dependent on teachers' strategies for implementing technology during classroom instruction. Researchers asserted that effectively implementing the TPACK model as a framework is dependent on teachers' ability and understanding to facilitate the use of modern educational technologies for their students during classroom instruction (Brantley-Dias & Ertmer, 2013; Koehler & Mishra, 2009; Koehler, Mishra, Kereluik, Shin, & Graham, 2014; Koh & Divaharan, 2013; Lin, Tsai, Chai, & Lee, 2013).

Lee and Kim (2014) contended that the application of the TPACK model has improved the implementation of technology integration in teachers' classroom teaching and students' academic growth in secondary education. In support of this notion, Mishra, Koehler, Schmidt, Baran, & Thompson (2009) argued that the TPACK model has provided strategies for resolving difficulties encountered by teachers during technology integration in their classroom teaching to improve students' learning outcomes. Mishra et al. posited that the TPACK model can be used to help teachers implement, describe, as well as document their technology and teaching skills. Mishira et al. maintained that the TPACK model can help teachers evaluate and effectively implement technology integration in their classroom teaching to improve students' learning outcomes.The TPACK model can be used to help teachers manage their instructional delivery and effectively implement technology integration in science.

The TPACK framework analysis was used to answer the research questions and support the problem and purpose of this study because it is a theory that was developed to explain the three sets of knowledge that teachers need to effectively teach their students in the classroom with technology (Lee & Kim, 2014). Figure 1 shows a conceptual map depicting how science teachers' use or application of TPACK and educational technology tools may enhance student-centered learning, engagement, performance, task accomplishment, and achievement levels in secondary science education.

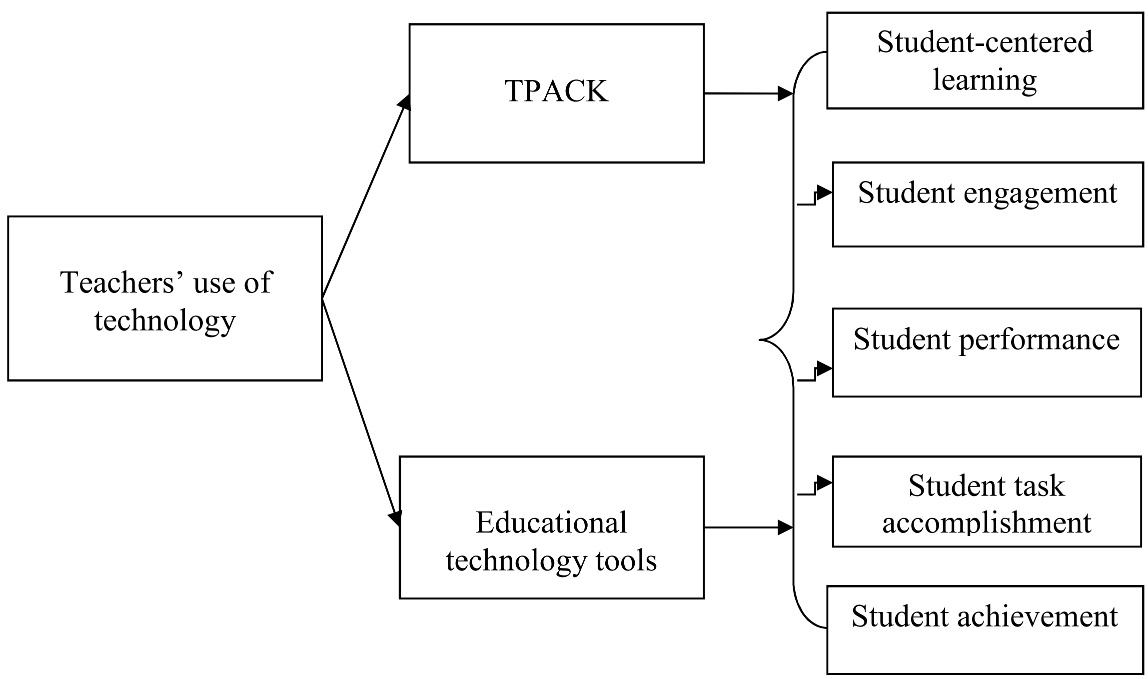

Figure 1.Conceptual research model of the current study.

Student-centered learning. Student-centered learning is a type of instructional approach, learning experience, and academic support to address the learning interests, desires, and cultural backgrounds of the learners. To achieve student-centered learning in the classroom setting, teachers and administrators in schools can use instructional delivery methods and strategies to effectively transform students' learning outcomes (Dondlinger, McLeod, & Vasinda, 2016).

Student engagement. The engagement of students in the classroom setting refers to the degree of motivation, interest, and curiosity that students exhibited during instructional activities. Teachers' facilitation of classroom learning increases when students are inquisitive and inspired about the content materials to be taught (Yin & Ke, 2017).

Student performance. Student performance in the classroom is determined through individual self-assessment of instructional assignments and projects. Students' self-assessment is the process whereby students use specific criteria to evaluate and reflect on their own work. Ultimately, the process helps students become more responsible for their own learning. Additionally, students are more focused and prepared to work with the teacher to develop individual self-assessment learning goals (Wang, Hwang, Liang, & Wang, 2017).

Student task accomplishment. Research literature indicated that the time students spend on classroom tasks is positively associated with academic growth. Students who are actively participating in their quest for knowledge acquisition and skill development take control of their learning in the classroom setting. These students will perform at high levels of task accomplishment during classroom instruction, projects, and activities (Mundilarto & Helmiyanto, 2017).

Student achievement. Student achievement in the classroom setting refers to the level of academic mastery of content materials that students develop in a particular period of time based on learning goals or instructional standards. Student achievement increases as the quality of teachers' classroom instruction improves (Deniz & Hatice-Oztburk, 2017).

Review of the Broader Problem

Use of Technology Integration for Effective Classroom Instruction

Educators have come to understand that integration of technology in classroom instruction for students made 21st-century learning possible (Sadaf, Newby, & Ertmer, 2016). Waters, Kenna, and Bruce (2016) posited that an essential feature for effective classroom instruction in district schools is integrating technology effectively in classroom instruction. According to Waters et al.'s study, integration of technology involves using technology resources for effective classroom instruction, including computers, mobile devices such as smartphones and tablets, digital cameras, social media platforms and networks, software applications, and the Internet. Waters et al. argued that these technological resources and tools are needed for effective classroom instruction in daily routine practices in secondary schools. Hollingsworth and Lim (2015) argued that effective classroom instruction is achieved when teachers' use of technology is routine, accessible, transparent, and readily available to solve classroom seatwork tasks, supporting curriculum goals and objectives and assisting students in attaining mastery skills.

Hutchison and Woodward (2014) argued that with the adoption of the common core state standards by most states, the use of digital tools for effective classroom instruction has become of great significance to educators. Hutchison and Woodward's study further indicated that effective classroom instruction is achieved when students are actively engaged in projects using technology integrated tools as a seamless part of the learning process. Muilenburg and Berge (2015) concurred, positing that for effective classroom instruction to be achieved, seamless technology integration must occur during classroom instruction. Seamless integration is achieved when students do not have technology available to them daily but have access to a variety of technology tools for classroom seatwork tasks and have the opportunity to build in-depth knowledge of the content.

Shlossberg and Cunningham (2016) contended that effective classroom instruction is achieved when students can use technology tools to obtain information on time, analyze and synthesize information, and present the information to other students. Almeida, Jameson, Riesen, and McDonnell (2016) posited that effective classroom instruction is achieved when technology combined with instruction increases learning and provides students access to current primary source materials in schools. Researchers have asserted that effective classroom instruction is achieved when the integration of technology provides teachers and students with methods of collecting data, ways to collaborate with others, opportunities for expressing knowledge using multimedia, relevant learning, authentic assessment, and training for presenting new knowledge (Denis, 2016; Gibson et al., 2014; Kramer, Neugebauer, Magenheim, & Huppertz, 2015; LeMire, 2016; Van Horne, Russell, & Schuh, 2016).

According to a research study by Sparapani and Calahan (2015), the integration of technology includes varied tools and instructional practices. Technology may be integrated into classroom instruction and the learning process in a variety of ways to promote students' learning outcomes in district schools. For example, integrating technology into the classroom may include the use of online learning, blended classrooms, project-based and research-based activities incorporating technology, game-based learning and assessment, learning with mobile and handheld devices, and other instructional tools. Instructional technology integrated tools in the classroom include interactive whiteboards, web-based projects, explorations, and research. Reiss and Millar (2014) supported this notion and posited that effective classroom instruction using technology can be achieved in schools if teachers receive appropriate professional learning on implementing educational technology into the curriculum to enhance students' learning. Implementing adequate professional learning in schools can support teachers' use of instructional technology tools in the classroom setting to improve students' learning outcomes.

Integration of Technology in Schools

Across the United States, school district personnel have encouraged the effective implementation of technology as a measure to reform teachers' instructional practices in the classroom setting (Farisi, 2016). Carver (2016) argued that effectively implementing technology and eliminating barriers to implementation in classroom instruction increased students' academic achievement in K-12 schools. Hsu (2016) concurred and asserted that effectively implementing technology has the potential to reform classroom instructional practices in various districts in the United States. According to the literature, schools make adequate yearly progress (AYP) and increase academic gains for students with varied learning styles by effectively implementing technology in classroom instruction (Roohi, Ahmad, & Jalal-ud-din, 2016; Scrabis-Fletcher, Juniu, & Zullo, 2016; Woo, 2015). Researchers have argued that educators should implement technology in classroom instruction to assist district schools in achieving the most favorable teaching and learning outcomes (Brenner & Brill, 2016; Elmendorf & Song, 2015; Hao & Lee, 2015; Lim, 2015; Pittman & Gaines, 2015; Ritzhaupt, Huggins-Manley, Dawson, Agacli-Dogan, & Dogan, 2017).

Effectively implementing technology would help teachers in facilitating classroom instruction that enables students to learn and make significant academic gain (Crompton, Olszewski, & Bielefeidt, 2016; Gonczi, Maeng, Bell, & Whitworth, 2016; Yu & Prince, 2016). Sparapani and Calahan (2015) argued that technology integration in mathematics and science instruction in secondary education offered the most support in teaching and learning to improve students' academic outcomes.

The International Society for Technology in Education (ISTE, 2016) personnel recommended technological initiatives and strategies to support the implementation of technology in the classroom. In addition, ISTE personnel recommended strategies to eliminate barriers impeding technology integration and implementation in schools. ISTE reported that technology use without students' possessing adequate technological skills does not improve academic growth. ISTE asserted that the technological skills students acquired from technology integration in the classrooms enabled them to coordinate classroom and learning activities in schools. ISTE standards indicated that teachers are key factors in technology's critical role in classroom instruction. ISTE standards outlined advantages of effective technology integration that teachers can use to facilitate classroom instructional practices. These included:

- Effectively implementing technology integration in classroom instruction enabled teachers to inspire student learning and creativity (p. 3).
- Technology integration when effectively implemented in classroom instruction enabled teachers to design and develop lesson activities that helped to improve students' learning and assessments (p. 3).
- Effectively implementing technology integration in teacher instructional practices enabled them to model appropriate content materials to enhance students' academic outcomes (p. 3).
- When teachers integrate and effectively implement technology in classroom instruction, they are able to provide appropriate formative and summative assessments for students to improve academic achievement (p. 2).
- Technology integration when effectively implemented in teacher instructional practices enabled them to engage in professional growth to enhance teaching and learning outcomes (p. 3).

ISTE standards contain suggested strategies that district schools use as initiatives to effectively implement technology integration to improve students' learning outcomes. ISTE standards advocate for districts to maximize their support for teacher's use of technology to facilitate classroom instruction in schools. In order to reap the benefits of technology integration in schools, it is important to understand the role of research on how to confront the barriers impeding effective technology use from the teachers' perspectives.

School Leadership Role in Technology Integration

School administration and leadership influences effective teacher implementation of technology in classroom instructional practices (Stevenson, Hedberg, O'Sullivan, & Howe, 2016). Vennebo (2017) posited that a key factor in instructional reform was school leadership's ability to assist teachers to infuse technology into the curriculum to improve students' academic growth. Webster (2017) asserted that the school leadership team has a major influence on teacher technological competencies because they supported teachers to improve technology integration in classroom instructional practices. In addition, the school leadership team supported teachers to increase student-centered learning, according to Webster. Webster's study emphasized the need for school principals to have technological knowledge so that they can support teachers to effectively implement technology integration into the curriculum. Hartley (2016) concurred, arguing that school leadership is pivotal to students' learning. Hartley maintained that the leadership team must assist teachers to model appropriate technology integration in classroom instruction to enhance student-centered learning, engagement, performance, task accomplishment, and achievement levels.

Persichitte (2016) argued that school leadership should focus more on how technology can effectively be implemented to promote students' academic growth. In support of this notion, Schrum and Levin (2016) contended that school leaders should assist teachers to foster effective technology integration in classroom instruction to improve students' engagement and academic outcomes. Schrum and Levin's study advocated for school leadership to prepare students for their future technology knowledge. Schrum and Levin emphasized the need to support teachers in adopting pedagogies to enhance teaching and learning. Schrum and Levin's research study recommended for a systems approach (how technology can benefit schools) to embrace technology implementation, address opportunities and challenges in infrastructure, promote pedagogy, improve students' learning, and teachers' classroom instructional practices. According to Schrum and Levin's study, a system approach addresses how technology usage can benefit district schools. A systems approach is a line of thought in technology management which stresses the interactive nature and interdependence of external and internal factors in an organization.

Affirming the quality of research in technology integration, Bogotch (2016) posited that leadership in today's schools should focus more in motivating and encouraging teachers to implement technology effectively into the curriculum to enhance students' academic growth. Bogotch's study emphasized that school leaders should provide opportunities for teachers to facilitate meaningful instructional activities in the classroom to improve students' achievement. Waite (2016) concurred and postulated that school leaders should encourage teachers to facilitate engaging instructional activities by effectively implementing technology into the curriculum to enhance students' academic outcomes.

In support of school leadership in technology integration, ISTE (2016) standards asserted that leaders should encourage the implementation of technology integration into the curriculum to promote students' optimal learning outcomes. According to ISTE standards, the benefits of effectively implementing technology in school leadership practices included the following:

- School leadership should focus on implementing technology into the curriculum to support students' learning goals and teacher effective instructional practices to maximize academic achievement (p. 5).
- School leadership should communicate how to implement technology-infused strategies into the curriculum for teachers to improve classroom instructional practices to promote student-centered learning (p. 5).
- School leadership should promote consistency in implementing technology into the curriculum to improve student-centered learning, engagement, performance, task accomplishment, and achievement levels in districts across the United States (p. 7).
- School leadership should allocate time and resources to ensure meaningful professional development for teachers to effectively implement technology (p. 7).

- School leadership should facilitate learning communities for teachers to improve classroom instructional practices to promote students’ engagement and classroom seatwork activities (p. 5).
- School leadership should lead instructional reform initiatives for teachers to maximize students’ learning goals through appropriate technology integration into the curriculum (p. 5).
- School leadership should encourage teachers to engage students in "critical thinking skills, problem solving, and decision making" by integrating technology tools such as simulations, games, videos, animations, and virtual laboratory in classroom instruction to enhance students’ learning (p. 7).

Meng and Law (2016) argued that school leadership should lead teachers to instructional reform initiatives to ensure students’ academic excellence. In support of this notion, Henriksen, Mishra, and Fisser (2016) maintained that school leadership efforts to infuse creativity and technology into the curriculum can bring change in classroom instructional practices to improve teaching and learning in the 21st-century education. Researchers asserted that school leadership are faced with many challenges in transforming instructional practices with technology integration, however, call for educators to undertake PD opportunities in implementing technology that is adaptive to instructional reform and change (Aidinopoulou & Sampson, 2017; Asuga, Scevak, & Eacott, 2016; Stevenson et al., 2016; Wine, 2016; Winslow, Dickerson, Weaver, & Josey, 2016; Yurtseven &Altun, 2017).

Charania and Davis (2016) posited that school leaders must acquire the knowledge to effectively implement technology integration to support students' academic needs and the learning environment so that they can lead instructional transformation initiatives. The research studies conducted by Asuga, Scevak, and Eacott (2016); Denham, Mayben, and Boman (2016); Law, Niederhauser, Christensen, and Shear (2016) reinforced the notion that school leadership is pivotal to effectively implement technology into curriculum and instruction to promote teaching and learning outcomes.

Effectively Implementing Technology in Secondary Science Education

The effective implementation of technology into instructional practices enhances learning in science (Guler & Sahin, 2015). Timur, Yilmaz, and Timur (2013) contended that science teachers with good instructional strategies are better able to assist other teachers in effectively implementing technology in science instruction. Technology, when implemented effectively, was found to enhance student academic skills and real-world experience in science. Researchers asserted that science teachers with good technological practices integrate technology in classroom activities and projects to enhance student-centered learning, engagement, performance, task accomplishment, and achievement levels (Bofill, 2013; Efe, 2015; Hechter & Vermette, 2013; Kanuka & Rourke, 2013; Minor, Losike-Sedimo, Reglin, & Royster, 2013; Nierkerk & Blignaut, 2014; Owens, 2015; Pryor, Akyeampong, Westbrook, & Lussier, 2012; Sundeen & Sundeen, 2013; Thomas & Ye, 2013). Bofill (2013) posited that students' task accomplishment were higher when technology were integrated into science lessons.

According to Bofill, students' critical thinking, problem solving, and decision making were higher when technology was effectively integrated into the curriculum.

Effective implementation of technology in the classroom enables teachers to facilitate classroom instruction that enhances student-centered learning in science (Bang & Luft, 2013; Ferreira, Baptista, & Arroio, 2013; Hakverdi-can & Dana, 2012; NSTA, 2015). Other studies concurred that effectively implementing technology assisted teachers to create an appropriate learning climate and raise science skills for students with varied learning styles (Gouseti, 2013; Hasni & Potvin, 2015; Kervin, Verenikina, Jones, & Beath, 2013; Potvin & Hasni, 2014). The effective implementation of technology created a learning environment that can increase students' cognitive efficacy by helping students to locate and create their own meaning and construct their own knowledge in science (Farisi, 2016). Wen-Yu Lee and Tsai (2013) investigated this phenomenon and found that students are actively engaged with technology in knowledge construction instead of passively receiving information. Their findings concurred with those of other researchers that teachers' technology integration in teaching science increased students' performance.

Effectively implementing technology in science classrooms enhanced students' learning outcomes in laboratory work and simulations (Al Musawi, Ambusaidi, Al-Balushi, & Al-Balushi, 2015; Hechter & Vermette, 2013; Hilton & Hilton, 2013; Kim, Kim, Lee, Spector, & DeMeester, 2013). Kayalar (2016) reported that the implementation of technology assisted teachers to facilitate students' use of computer software such as virtual laboratory and simulations to retrieve information for science research studies and other laboratory related projects. The implementation of technology through virtual laboratory and simulations as a teaching tool is used to make required changes in science to enhance student-centered learning (Acikalin, 2014; Elmas, Akin, & Geban, 2013; Kovalik et al., 2014; Laferriere, Hane, & Searsont, 2013; Majid, 2014). Effective implementation of technology enables teachers to facilitate classroom instruction to aid student-centered learning in science.

Bang and Luft (2013) reported on the implementation of technology designed to enhance the use of science experimental models and students' clarification of science laboratory investigations. Acikalin (2014) reinforced the need to use technology to aid student-centered learning in science. Discovering avenues for technology implementation and to combat barriers for effective technology integration in science instructional practices is a challenge confronting teachers across district schools in the United States.

Below are the details of the educational technology tools recommended by the southeastern U.S. school district for teachers to use and improve classroom teaching in science. The name and key features of educational technology tools are displayed in Table 1 below.

PhET Interactive Simulations Project of University of Colorado. According to PhET Interactive Simulations Project of Colorado (https://phet.colorado.edu), the site provides interactive mathematics simulations. The organization is testing and evaluating each simulation to ensure educational effectiveness. All simulations are open source. The sponsor of PhET project makes it possible for the resources to be free to all students and teachers. The PhET Interactive Simulations Project is for students in all science subjects and grades 6-12 (PhET Interactive Simulations Project, 2017).

The Concord Consortium Next-Generation Molecular Workbench. According to Concord Consortium Next-Generation Workbench (http://mw.concord.org/nextgen/#activities), the site provides visual, interactive, computational experiments for teaching and learning science to improve students' engagement and achievement levels. The Concord Consortium Next-Generation Molecular Workbench is meant for students in biological sciences and grades 9-12 (Concord Consortium, 2017, p. 2).

The High Adventure Science project by Concord Consortium. According to High Adventure Science Project by Concord Consortium (http://has.portal.concord.org), use of the program injects contemporary earth and space science into the classroom to improve students' engagement, performance, and achievement levels. The High Adventure Science Project is for students in all science subjects and grades 9-12 (Concord Consortium, 2017).

The Genetic Science Learning Center at the University of Utah. According to Genetic Science Learning Center at the University of Utah (http://genetics.utah.edu), use of the program translates science and health fields to non-experts to improve teaching and learning thereby raising students' achievement levels. The Genetic Science Learning Center is for students in biological sciences and grades 9-12 (Genetic Science Learning Center, 2017).

The WGBH Educational Foundation and Public Broadcasting Service (PBS). According to WGBH Educational Foundation and Public Broadcasting Service (http://www.pbs.org/wgbh/nova/evolution/guess-embryo.html), the site offers "media resources appropriate for PreK-16 curriculum for use in the classrooms, homeschool, and informal educational environments, such as after-school, community facilities, and museums" to improve students' engagement, performance, and achievement levels. The WGBH Educational Foundation and Public Broadcasting service is for students in all subject areas and grades PreK-12 (NOVA, 2017, p. 4).

YouTube. According to YouTube (https://youtube./uBG12BujkPQ), the site provides a forum for people to connect, inform, inspire, and watch originally created videos to improve students' engagement, performance, and achievement levels. YouTube is for students in all subject areas and grades PreK-12 (YouTube, 2017).

Kahoot. According to Kahoot (https://getkahoot.com), the site assists in motivating participation through game-based learning and rewards in a classroom and social setting to improve students' engagement, performance, and achievement levels. Kahoot is for students in all subject areas and grades 6-12 (Kahoot, 2017).

Table 1

Key Features of Educational Technology Integration Tools

Name of technology	Features
PhET Interactive Simulations (https://phet.colorado.edu)	Interactive, research-based, effective, Java, Flash, or HTML.5, visual, online, and free to users.
Next-Generation Molecular (http://nw.concord.org/nextgen#activities)	Interactive, visual, STEM-based, online, download, experimental, videos, and free to users.
High Adventure Science (HAS; http://has.portal.concord.org)	Earth and space science, hands-on, answer science questions, online, visual, videos, and free to users.
University of Utah Genetics (http://genetic.utah.edu)	Translation of science and health programs, online, and free to users.
NOVA Broadcasting Service (http://www.pbs.org/wgbh/nova/evolution/guess-embryo.html)	Classroom-ready and curriculum-targeted digital resources, videos, interactive, audio, Pre-K to Grade 12, science, lesson plan, online, and free to users.
YouTube (https://youtube/uBG12BujKPQ)	Science video clips, online, and free to multiple users.
Kahoot (https://getkahoot.com)	Game-based learning, research-based, online, engaging activities, technology enhanced learning, and free to users.

The Importance of Effectively Implementing Technology to Improve Instruction

The importance of effectively implementing technology to improve classroom instruction among school districts cannot be ignored. Hsu (2016) asserted that the implementation of technology integration to improve classroom instruction is important because it is an approach that can be used to reform teachers' instructional practices. Woo (2015) concurred, positing that the implementation of technology integration is significant in helping teachers to facilitate instruction to enhance teaching and learning outcomes. Affirming the quality of research in the importance of effectively implementing technology to improve classroom instruction, researchers argued that when technology is effectively implemented in the classroom, it enables teachers to engage students in instructional activities and improve their teaching practices (Efe, 2015; Eristi & Dindar, 2012; Murthy, Iyer, & Warrien, 2015; Pittman & Gaines, 2015; Roohi & Ahmad, 2016). Erguvan (2014) declared that effectively implementing technology is important to improve classroom instruction because it enables teachers to be effective in facilitating classroom instruction using tools such as simulations, games, videos, animations, and virtual laboratory. Erguvan's study asserted that effective use of technology through teachers' facilitation of instruction made it possible for students to engage in classroom activities to enhance teaching and learning outcomes.

Brenner and Brill (2016) affirmed the importance of effectively implementing technology to improve classroom instruction by maintaining that effective use of technology helped teachers to personalize instruction. In addition, Brenner and Brill maintained that effectively implementing technology is important to meet the needs of students with varied learning styles. ISTE (2016) standards discussed that personalizing instruction to meet the needs of students with varied learning styles allows teachers to work with students one-on-one in classroom activities. ISTE standards discussed that teachers personalize learning activities to address students' diverse learning styles, working strategies, and abilities by using technology as an instructional tool and resource.

Gupta and Fisher (2012) argued that effectively implementing technology helped teachers to strengthen classroom instruction. According to Gupta and Fisher's study district schools should use technology to empower teachers in strengthening classroom instruction to enhance students' learning outcomes. Teachers should take the adoption of technology as part of their lesson planning to improve classroom instruction. Teachers should not be afraid of open-source technologies and endeavor to use online education portfolios to evaluate their students' academic perfoormance. Gupta and Fisher recommended that teachers should embrace the common core state standards to strengthen their instructional practices to improve students' learning outcomes.

Cubukcuoglu (2013) argued that effectively implementing technology to enhance instruction enabled teachers to create a positive classroom climate to improve students' learning outcomes. According to Cubukcuoglu's study, effectively implementing technology assisted teachers to introduce an interesting curriculum based on real-world problems. Effectively implementing technology to improve classroom instruction assisted teachers' instructional practices to provide scaffolds and technological tools to enhance students' learning outcomes. Teachers, who implement technology effectively, create more opportunities for feedback, reflection, and revisions to enhance students' learning outcomes.

Lee, Waxman, Wu, Michko, and Lin (2013) posited that effectively implementing technology is important to impove classroom instruction because it assisted teachers in their teaching. It is also an important factor for raising academic achievement levels in all content areas, including science. Lee et al.'s study emphasized that strong gains in academic achievement occurs with effective technology integration to improve classroom instruction when teachers provide real-time support and encouragement to underserved students in the classroom setting. Lee et al. contended that technology access policies should aim to instruct students on one-to-one computer access as an instructional tool. Lee et al. further argued that curriculum and instruction plans should enable students to use technology to create content as well as learn the material to raise academic growth and achievement. The effective use of technology to improve classroom instruction has been recognized to be major components of teaching and learning by researchers.

According to ISTE (2016) standards, effectively implementing technology to improve classroom instruction enhanced teachers' instructional practices to do the following:

- Technology integration in classroom instruction enabled teachers to advance student learning, innovation, creativity to lesson activities in the classroom setting and virtual environments (p. 3).

- Technology integration in classroom instructional practices enabled teachers to promote and support students' inventive thinking in the classroom setting (p. 3).
- Technology integration in classroom instruction allowed teachers to engage students in exploring real-world problems and solving authentic problems using technology tools available for learning in the classroom setting (p. 3).
- Technology integration in classroom instruction enabled teachers to encourage collaboration among students, and clarify students' conceptual understanding of content materials to improve learning outcomes in schools (p. 3).
- Technology integration in classroom instruction enabled teachers to use technology to maximize content learning and mastery of skills in all content areas, specifically science in districts across the United States (p. 2).
- Technology integration in classroom instructional practices assisted teachers to encourage students to set their learning goals using technology to improve academic achievement in various schools across the United States (p. 2).
- Technology integration in classroom instructional practices enabled teachers to provide students with teacher-made tests, formative assessments, summative assessments aligned with content materials, and used resulting data to inform students' achievement in district schools (p. 3).

The application of technology integration to improve classroom instruction enables teachers to be effective in facilitating lesson activities rich in problem solving and high order thinking skills. Higher order thinking skills involve teachers' use of technology to engage students in exploring real-world issues and solving authentic problems as well as teachers' use of technology in classroom instruction to promote and support inventions and innovative thinking (ISTE, 2016).

In a research study by Al-rsa'i (2012), the researcher argued that technology integration to improve classroom instruction enabled science teachers to be effective in transforming their approach to lesson activities and teaching practices in the classroom to improve student performance. Al-rsai's study indicated the need for teachers' use of technology to engage students in exploring real-world issues, resolving authentic problems, cognitive skills, logical thinking skills, reflective thinking skills, metacognitive thinking skills, and creative thinking skills to enhance students' learning outcomes (McKnight & Ramnarine-Rieks, 2014; Tath & Ayas, 2012). Al-rsai's study noted that effectively implementing technology to improve classroom instruction enabled teachers to promote students' construction of knowledge, invention, decisions, explanations, performances, support for innovation thinking, and lower order thinking skills such as content discriminations, simple application and analysis, and cognitive strategies.

Researchers asserted that effectively implementing technology to improve classroom instruction is important in comparing face-to-face and Internet based instruction from the teachers' perspectives. These researchers found that implementing technology effectively enables teachers to be more successful in facilitating classroom instruction (Adams, et al 2012; Alayyar, Fisser, & Voogt, 2012; Broussard, Hebert, Welch, & VanMetre, 2014; Cakiroglu, Akkan, & Guven, 2012; Hagerman, Keller, & Spicer, 2013; Lin, Chang, Tsai, & Kao, 2015). The importance of effectively implementing technology to improve classroom instruction helped teachers' facilitation of instruction through video streaming that created a clearer picture for students' understanding of concepts in all subject areas including science (Adams et al., 2012).

Alayyar, Fisser, and Voogt (2012) posited that effectively implementing technology to improve classroom instruction is important because it helped teacher instructional practices through electronic games that use iPads and tablets to engage students in classroom activities in any subject areas. Effectively implementing technology to improve classroom instruction helped teacher instructional practices through social media by using Facebook or Twitter to engage students in classroom interactive activities, according to Alayyar et al. Using Facebook or Twitter in the classroom helps teachers to transform classroom instruction from traditional teaching tools to an interactive technology tools through social media.

Cakiroglu, Akkan, and Guven (2012) found that effectively implementing technology to improve classroom instruction is important because it helped teacher instructional practices through blogs by assisting students to post their class work online and podcasts as a learning tool for students to review class lesson. Teachers who effectively integrated technology to improve classroom instruction provide an online materials to enhance students' learning. Effectively implementing technology to improve classroom instruction is best achieved when teachers create classroom podcasts to improve students' learning. In support of this notion in the importance of implementing technology to improve classroom instruction, Oliver, Osa, and Walker (2012) found that effectively implementing technology to improve classroom instruction is important because it helps teacher instructional practices through video conferencing that allows students to travel globally from their classroom. Oliver et al. noted that implementing technology effectively to improve classroom instruction assists students to use mobile devices in collaborative group work. Teachers who integrate technology effectively to improve classroom instruction facilitate group work activities using mobile devices to collaborate with one another in the classroom setting.

According to Broussard, Hebert, Welch, and VanMetre (2014), integrating technology effectively to improve classroom instruction is important because it influenced students to purchase a personal computer to enhance their learning inside and outside of the classroom. Effectively integrating technology to improve classroom instruction is important for students to use their own personal computer to help teachers differentiate instruction. Teachers were cognizant how they teach and how the students demonstrated what they learned. Integrating technology effectively to improve classroom instruction is important because it helps teachers to individualize students' instruction through the use of adaptive technology.

Gebre, Saroyan, and Bracewell (2014) posited that effectively implementing technology to improve classroom instruction is important because it enhanced classroom instruction more than the traditional method of teaching. Incantalupo, Treagust, and Koul (2014) concurred, maintaining that effectively implementing technology to improve classroom instruction is important because it helped teachers to enhance students' knowledge. The importance of effectively implementing technology to improve classroom instruction is important because it helps teachers to increase students' knowledge of content through simulations and virtual manipulations, global learning, efficient assessment, active classroom participation, and more opportunities for classroom instructional feedback.

Whetstone, Clark, and Flake (2014) asserted that effectively implementing technology to improve classroom instruction helps teachers to facilitate classroom instruction to enhance students' academic gain. Effectively implementing technology to improve classroom instruction enables teachers to promote students' high levels of interactivity and engagement through classroom activities. Esterhuizen (2012) concurred with the idea and contended that implementing technology effectively to improve classroom instruction is important because teachers can support students' computer literacy to enhance learning. Discovering the students' perceived computer literacy would strengthen the value of effectively implementing technology to improve classroom instruction as well as useful for educators to resolve the gap in student achievement in various district schools in the United States.

Technology Integration and School Policy Making

Hew and Tan (2016) argued that despite technology integration's vital role in simplifying teaching and learning to make academic gain in schools, stakeholders and policy makers continually use technology to foster learning communities across the United States. It is believed that technology integration in school policy making principles would encourage students' cognitive skills and resolution skills in schools. According to Hew and Tan, stakeholders, administrators, and teachers believed that effectively integrating technology in the school educational environment would enhance pedagogical instruction. Researchers supported this notion asserting that technology integration and school policy supports the curriculum by using technological tools such as simulations, games, videos, animations, and virtual laboratory to improve students' academic outcomes (Insera & Short, 2012-2013; Lim, Zhao, Tondeur, Chai, & Tsai, 2013; Lin, Chang, Tsai, & Kao, 2015; Moller, Haas, & Vakilzadian, 2013; Mundy, Kupczynski, & Kee, 2012; Whetstone et al., 2014; Yang & Leung, 2015).

Yu and Prince (2016) posited that effectively integrating technology in schools' policy making principles would improve a shared vision of how technology can support teaching and learning. Effectively integrating technology in policy making principles in schools is dependent on the administration of successful policy development by the stakeholders and the school leadership team (Yu & Prince, 2016)). It is imperative for stakeholders charged with school policy making to use assessment and evaluation techniques to inform decision making in school environment. The assessment and evaluation techniques would ensure continuous improvement in teaching and learning outcomes in schools.

Barriers to Effectively Implementing Technology in Schools

Banas and Polly (2016) contended that ensuring teachers and students experience success using technology, district schools should endeavor to eliminate barriers impeding the effective implementation of technology use. In addition, Ruggierro and Mong (2015) asserted that it is imperative for educators to eliminate barriers impeding implementation of technology integration in classroom instruction so that schools can make sufficient students' academic gain.

In support of this notion, researchers affirmed that barriers impeding teachers' technology integration in the classroom includes teacher attitudes towards the use of computers, lack of teacher confidence to technology use, teacher resistance to change, lack of time devoted to technology instruction, poor funding for technology, and lack of computer skills, and technical difficulties or problems confronting teachers' use of technology in the classroom (Banas & Polly, 2016; Gonczi, Maeng, Bell, & Whitworth, 2016; Hechter & Vermette, 2013; Karaoglan, Fatma, Yilmaz, Ozturk, Sezer, & Karademir, 2015; Kopcha, 2012; Laferriere et al., 2013; Pittman & Gaines, 2015).

Carver (2016) posited that it is imperative to address these barriers impeding the implementation of technology integration in teacher instructional practices to achieve the benefits of technology use to improve teaching and learning in K-12 schools. Hsu (2016) concurred, arguing that the elimination of barriers to technology use enhances student-centered learning. Hsu maintained that when teachers are unable to identify and eliminate these barriers to effective technology integration, they are not competent enough to implement technology successfully into the curriculum.

Technology Tools Used in Science Education

Below are the details of educational technology tools that are available to teachers to use and improve classroom instruction in science. Some of these educational technology tools are currently being used by science teachers at the project study site as shown in table 2.

Science Channel—YouTube. According to YouTube's description of Science Channel (https://www.youtube.com/user/sciencechannel), the site provides an effective pedagogical practice used by science teachers in the classroom setting to improve student-centered learning, engagement, performance, task accomplishment, and achievement levels through science video clips. Science teachers used the technology tool via video clips for lesson in biology, earth and space science, physical science, physics, chemistry, anatomy and physiology. It is free to teachers and students. The Science Channel is for students in all science subjects and grades P-12 (YouTube, 2017).

Science Links. According to Science Links (http://www.scilinks.org), the site is used by science teachers through the National Science Teacher Association (NSTA) as an organization that provides science activities and interactives to enhance teaching and learning. Science teachers incorporated the technology tool into their lesson to enhance students' engagement and knowledge during classroom activities. Science teachers and students have free access. The Science Links is for students in all science subjects and grades 6-12 (NSTA, 2015).

Khan Academy. According to Khan Academy (https://www.khanacademy.org), the site provides science tutorial and activities for science teachers and teachers from other content areas to enhance their lesson objectives with students in the classroom setting. Khan Academy is an organization that provides free access to the technology tool for teachers and students. Khan Academy is for students in all science subjects and grades 6-12 (Khan Academy, 2017).

Best of Science—YouTube. According to YouTube's description of Best of Science (www.youtube.com/user/BestofScience), the site provides the best of science video clips for science teachers to access and improve their classroom instruction.

Science teachers integrated the technology tool to enhance students' learning. Access to the technology tool is free to teachers and students. Best of Science is for students in all science subjects and grades P-12 (YouTube, 2017).

The Physics Classroom. According to the Physics Classroom (http://www.physicsclassroom.com), the site provides physics tutorial, interactives, and Internet modules for science teachers to use and enhance their classroom instruction. Science teachers incorporated the technology tool into their lesson and class activities to enhance students' learning. Teachers and students have free access to the technology tool. The Physics Classroom is for students in all science subjects and grades 9-12 (Physics Classroom, 2017).

Brain POP. According to Brain POP (https://www.brainpop.com), the site provides animated science interactives for students. Science teachers incorporated the technology tool into their lesson activities to enhance teaching and learning. Access to the technology tool is free to teachers and students. Brain POP is for students in all science subjects and grades P-12 (Brain POP, 2017).

C. Stephen Murray Science. According to C. Stephen Murray Science (http://www.cstephenmurray.com/science/index.htm), the site provides solutions to physics, chemistry, and biology for science teachers to incorporate into their classroom lesson activities with students. Science teachers used the technology tool to enhance students' learning in science. Access to the technology tool is free to teachers and students. C. Stephen Murray Science is for students in all science subjects and grades 9-12 (C. Murray Science, 2017).

Science Net Links. According to Science Net Links (http://sciencenetlinks.com), the site is used by science teachers to find science lessons and tools for K-12 students. Teachers used the technology tool to enhance classroom instructional activities for students' learning. Teachers and students have free access to the technology tool. Science Net Links is for students in all science subjects and grades K-12 (Science Links, 2017).

AAAS Project 2061 Science Assessment. According to AAAS Project 2061 Assessment (http://assessment.aaas.org), use of the program enabled science teachers to create and take tests with students. Science teachers used the technology tool to improve students' mastery skills in science. The technology tool is for science teachers' use to promote students' learning. AAAS Project 2061 Science Assessment is for students in all science subjects and grades 6-12 (Project 2061, 2017).

Annenberg Learner. According to Annenberg Learner (http://www.learner.org/interactives), the site provides science interactives and other content areas. Science teachers used the technology tool for the integration of lesson activities during classroom instruction. Science teachers used the technology tool to enhance students' learning. Access to the technology tool is free to teachers and students. Annenberg Learner is for students in all science subjects and grades 6-12 (Annenberg Learner, 2017).

Biology4Kids. According to Biology4Kids (http://www.biology4kids.com), the site provides interactives in biology topics such as cell structure, cell function, scientific studies, plants, vertebrates, and invertebrates for science teachers to incorporate into their classroom lesson activities to enhance students' learning (p. 3). The technology tool is free to teachers and students. Biology4Kids is for students in all science subjects and grades 9-12 (Biology4Kids, 2017).

Cells Alive. According to Cells Alive (http://www.cellsalive.com), use of the program provides science simulations and interactives for science teachers to incorporate into their classroom lesson activities to enhance teaching and learning. Access to the technology tool is free for teachers and students. Cells Alive is for students in all science subjects and grades 6-12 (Cells Alive, 2017).

Biology Corner. According to Biology Corner (http://www.biologycorner.com), the site provides science tutorials, worksheets, hands-on science labs, lessons, and teacher resources for science teachers to incorporate into their classroom activities with students to enhance teaching and learning. Access is free for teachers and students. Biology Corner is for students in all science subjects and grades 9-12 (Biology Corner, 2017).

Biology Alive. According to Biology Alive (http://biologyalive.com/life/index.html), the site provides tutorial, worksheets, and teacher resources in biology, advance placement biology, microbiology, genetics, and anatomy and physiology for science teachers to incorporate into their classroom instruction to enhance students' centered learning, engagement, performance, task accomplishment, and achievement. The technology tool provides free access to teachers and students. Biology Alive is for students in all science subjects and grades 9-12 (Biology Alive, 2017).

Table 2

Key Features of Other Educational Technology Integration Tools

Name of technology	Features
Science Channel, YouTube (https://www.youtube.com/user/sciencechannel)	Science video clips and free to users.
Science Links (https://www.scilinks.org)	Science activities and interactives. Free to users.
Khan Academy(https://www.khanacademy.org)	Science tutorials, activities, and free to users.
Best of Science, YouTube (www.youtube.com/user/BestofScience)	Science video clips and free to users.
The Physics Classroom (http://www.physicsclassroom.com)	Science tutorials, interactives, and Internet modules. Free to users.
Brain POP (https://www. brainpop.com)	Animated science interactives, and free to users.
C. Stephen Murray Science (http://www.cstephenmurray.com/science/index.htm)	Solutions to physics, chemistry, and biology. Free to users.
Science Net Links (http://sciencenetlinks.com)	Science net links and solutions to K-12 students. Free to users.
AAAS Project 2061 (http://assessment.aaas.org)	Create and take test.
Annenberg Learner (http://www.learner.org/interactive)	Science and other content field interactives. Free to users.
Biology4Kids (http://www.biology4kids.com)	Interactives in biology such as cell structure, cell function, scientific studies, plants, vertebrates, and invertebrates. Free to users.
Cells Alive (http://www.cellsalive.com)	Science simulations and interactives.
Biology Corner (http://www.biologycorner.com)	Science tutorials, worksheet, hands-on, science labs, lessons, and teacher resources.
Biology Alive (http://biologyalive.com/life/index.html)	Biology tutorial, worksheet, teacher resources in biology, advance placement (AP) biology, microbiology, genetics, anatomy and physiology.

Summary of Literature Review

The existing literature clearly revealed the current state of implementation and barriers to effective technology integration in classrooms including science classrooms across the United States. The literature review presented the factors necessary for supporting teachers' use of technology and barriers impeding its use in classroom instructional practices. The literature portrayed the factors that are relevant for addressing the problem of teachers' implementation and barriers to effective technology integration in classroom instructional practices. The literature laid emphasis on how the effective implementation of technology integration in classroom instructional practices could be a medium to facilitate instruction to improve student-centered learning, engagement, performance, task accomplishment, and achievement levels. Ultimately, the literature focused on classroom instructional practices to support teachers' use of technology and barriers impeding technology use in school districts across the United States. As noted by Hew and Tan (2016); Hsu (2016); Ritzhaupt, Huggins-Manley, Dawson, Agacli-Dogan, and Dogan, 2017; Yu and Prince (2016) it is imperative for educators to recognize the critical factors in understanding the challenges and successes of effectively implementing technology in classroom instructional practices. The saturation of the literature has been achieved through repeated themes, concepts, and ideas from researchers who explored the technology integration and barriers impeding technology use into the curriculum to enhance students' outcomes.

Implications

Koski and Vries (2015) posited that efficient teachers implement technology to personalize learning for each student. However, research studies asserted that many educators did not know how to effectively implement technology into the curriculum (Ayhan, Muge, & Sukru, 2015; Hacieminoglu, 2014; Hsu, 2016; Swanson, 2014; Weston and Bain, 2015). Since the United States Department of Education adopted the implementation of ISTE standards into the curriculum for teachers, administrators, and students, many educators failed to incorporate technology in their instructional practices (U.S. Department of Education, 2012).

Downes and Bishop (2012) argued that since the students in secondary education has more need to acquire 21st-century technology than other groups, it is imperative that secondary education teachers understand how to effectively implement technology integration. In order to meet the needs of students in technology literacy in the 21st-century, Gunn and Hollingsworth (2013) argued that teachers must understand how to effectively implement and integrate technology into the curriculum.

The implications from this study may assist in the transformation process from face-to-face learning to blended learning via online learning. This project study may provide insight on how teachers should improve the effective implementation of technology integration into the curriculum. Recommendations may include the professional learning coordinators to revisit the appropriate methods of training necessary to improve teachers' effective implementation of technology integration into the curriculum to enhance students' learning outcomes.

Summary

Teachers are arguably the most important variable in delivering effective technology instruction in science classrooms. Research studies on the effective implementation to technology integration into the curriculum presented teachers as the major factor in achieving successful use of technology in classroom instruction. Technology integration provides students the opportunity to investigate and find solutions to real-world problems. Effective technology integration provides students the avenue to interact with people of diverse cultures, develop collaborative skills with others, and become active in the global economy. Section I examines the role of technology integration in education, new methods and ideas in classroom technology use, elimination of barriers to technology integration into the curriculum, and the technological tools available for effective technology implementation into the curriculum to enhance students' learning outcomes.

Section 2 provides details for the methodology framework that includes research design and approach, participants, data collection, and data analysis.

Section 2: The Methodology

Research Design and Approach

Introduction

This project study addressed the specific problem of how high school teachers in a southeastern school district integrated technology in their classroom teaching to improve students' learning outcomes in science. Research designs are procedures used during data collection and data analysis (Creswell, 2012). In this methodology section, I provide the rationale for the research design and approach used to explain the local problem. The research questions for this study addressed how high school science teachers implemented technology in their STEM classes and their technology, pedagogy, and STEM content knowledge at the southeastern school district under study.

To address the research questions, I used a qualitative research method and a case study research design (Merriam, 2009). A case study is a bounded system used to study a common phenomenon within a specific context (Creswell, 2012; Merriam, 2009). A bounded system helps me to understand the boundaries of the case and the complexity of participants' behavior patterns (Stake, 1983, p. 283). A phenomenon helps me to observe the occurrence of the event, such as technology use. A context helps me to understand how teachers in a science class (context) in one southeastern school district (context) experienced the phenomenon. These two examples of context are based on the research objectives and frames my study. My reason for choosing a case study design was that I sought to examine how teachers integrated technology in their classroom teaching using the TPACK framework. In this case study, data collection included document review

(Appendix B) and open-ended interviews (Appendix C). The data collection methods helped in answering the research questions through the responses provided by participants during the interviews regarding effectively implementing technology integration in their classroom teaching of the STEM curriculum. Open-ended interviews and document review of teachers' lesson plans were the two forms of data chosen for my study. The two research questions aligned with the interviews and document review (lesson plans) because these two data collection tools are generally used in qualitative bounded case study research (Merriam, 2009) and both involve collecting data specifically related to the research questions and the study problem.

In the following subsections, I describe the local setting and the ethical standards associated with participant access and protection. A detailed description of the data collection and data analysis procedures is also included. Answers to the research questions were developed through data analysis and were supported by responses from participant interviews. A general description of the procedures that I used to maintain the quality of research is provided. I discuss data collection procedures for the documents and interviews. I then discuss how data were analyzed using typological analysis. I conclude by discussing the data analysis results, including the project deliverable.

Qualitative Research Design and Approach

According to Yin (2009), the purpose of case study research is to show real-life experiences indepth (p. 4). Qualitative research is used to address *why* and *how* questions concerning a phenomenon; thus, qualitative research was optimal for studying how teachers integrated technology into their classroom teaching to improve students' learning outcomes in science.

A phenomenology approach was proposed and rejected for this study because phenomenology focuses on the experiences of individuals as they lived them (Merriam, 2009). My study was about teachers' effective implementation of technology integration rather than their experiences related to social processes and cultures. Merriam (2009) asserted that a key characteristic of phenomenology is that it is person centered rather than being concerned with social processes and cultures. The phenomenology approach was not appropriate for this study because the objective of this approach is to understand how people construct the meaning of a specific phenomenon.

Ethnography was considered and rejected for this study because the aim of ethnographic study is to investigate a focus culture by studying its members (Merriam, 2009). My study was about teachers' technology implementation and their technology knowledge, rather than a specific culture or members of that culture. Further, the ethnographic approach requires a large amount of the researcher's time. Merriam (2009) contended that an important characteristic of the ethnographic approach is that it focuses on everyday behaviors of members of a culture, which was not part of my study. The ethnographic approach was not appropriate for this study because my intent was not to identify cultural norms, beliefs, social structures, and other cultural patterns.

Grounded theory design was also considered and rejected for this study because it is used when a researcher intends to develop a broad explanation or build a substantive theory about a phenomenon of interest (Merriam, 2009). Merriam (2009) posited that an essential characteristic of a grounded theory design is that it is used to generate a theory involving the identification of a core category (p. 31). Grounded theory design was not appropriate for this study because it addresses processes or change over time. The goal of this study was not to develop a theory of technology implementation, but to explore how teachers implemented technology in high school STEM classes and to explore teachers' technology, pedagogy, and STEM content knowledge.

The historical approach was considered and rejected for this study because the aim of this design is to analyze events that occurred in a current or isolated past (Merriam, 2009). Merriam (2009) stated that a significant characteristic of the historical approach is that it uses first-person accounts of experience (p. 32). A historical approach was not appropriate for this study because such an approach focuses on the philosophy of hermeneutics (study of written text). In further argument, Merriam stated that the historical approach uses biographical, psychological, and linguistic approaches, which did not support this study.

Qualitative case study was selected for this study because this approach is used to research a unit of study (Merriam, 2009). A qualitative case study researcher searches for meaning and understanding in an investigation that produces richly descriptive data. Because the behaviors of participants and the setting of a case study are not manipulated as in experimental research, a case study presents a true and accurate account of the experiences of an individual or group of people (Creswell, 2012; Johnson & Christensen, 2004; Merriam, 2009, 2011; Yin, 2009).

Participants

A total of 12 teachers from a pool of 18 teachers in the science department at the project study site were purposefully selected to participate in the study based on individual attributes (Merriam, 2009). Science teachers who were eligible to participate and met the following criteria were the selected participants for the study. They needed to be (a) performing teaching duties on a full-time or part-time basis, (b) certified science teachers eligible to work for the southeastern school district, (c) integrating technology into their classroom teaching to improve students’ learning outcomes in science, and (d) science teachers using educational technology to teach students in the classroom for at least 1 year.

A sample of 12 participants was selected from the population of 18 teachers in the science department. A small sample is appropriate for a qualitative case study because the case is explored indepth (Creswell, 2012; Johnson & Christensen, 2004; Yin, 2009). The smaller sample size of 12 participants was used to maximize the breadth and depth of the data gathered from each participant in the study.

A purposeful sampling frame was used for this study because the cases, the participants, were knowledgeable about the phenomenon (Yin, 2009). Patton (2015) referred to such cases as information-rich because they can produce in-depth understanding of a specific phenomenon. This inquiry fit my study because only science teachers who had integrated technology in STEM classes had the requisite knowledge and were invited to participate.

Access to Participants

Mackenzie and Knipe (2006) posited that for participant interviews to occur, a researcher must obtain entry to the study site. I obtained entry to the project study site by submitting an application to the district's research office seeking permission to conduct a research study. After obtaining permission from the district's research office, I scheduled a meeting with the high school principal to explain the details of the project study and seek permission to conduct the study at the school site. Upon receiving the principal's approval, I requested that the school principal introduce me to the administrators and science department chairperson. Additionally, I requested that the science department chairperson introduce me to the science teachers who served as participants for the study. A meeting to explain the purpose of my project study to the school administrators, science department chairperson, and the teachers at the school site was scheduled. During the meeting, I requested that the science department chairperson help me by providing the science teachers' e-mail addresses. All 18 science teachers from the study site received a letter of invitation that introduced and described the justification for the research study and offered them the opportunity to volunteer to participate in the study. I explained the details of the study and answered any questions or concerns from the participants. The times for the interviews were scheduled at the school site. I thanked the participants for fulfilling their role and for supporting my study.

Researcher-Participant Relationship

One of the actions that I used to create a collaborative relationship with participants was clearly communicating the purpose of the study. At the science department meeting with the participants, I shared the purpose for the research study; described the data collection methods, including review of teachers' lesson plans and interviews; stated how long the interviews would last; and provided my contact information. Qualitative experts have recommended clearly sharing such information to inform participants of their obligations in a study (Creswell, 2012; Hatch, 2002; Patton, 2002; Yin, 2009). I informed all participants of my expectations and discussed obligations throughout the study process. I showed participants in this study utmost respect, with special consideration for the time that they invested in the study effort. Hatch (2002) asserted that participants were asked to exercise trust in sharing the intimate details of their technology integration. In support of this notion, Merriam (2009) posited that because participants are in control of the depth of information that they provide during interviews, establishing good researcher-participant relationships is necessary to ensure that participants understand the purpose of the study in simple terms.

Ethical Protection of Participants

I was obligated to conduct ethical research to protect the rights of the participants and Walden University. Yin (2009) posited that this obligation is achieved in part by gaining informed consent, avoiding deception, protecting the rights and privacy of participants, and protecting participants from harm. Permission was obtained from the district's research director and the school principal to conduct the study. After receiving approval from the school principal to conduct the study at the school site, I requested that the principal introduce me to the administrators and the science department chairperson. After my introduction to the science department chairperson, I requested that the science department chairperson introduce me to the science teachers who might serve as participants in the study. All 18 science teachers from the study site received a letter of invitation that introduced and described the justification for the research study and offered an opportunity to volunteer as a study participant. At this meeting, I shared the purpose of the research study; described the data collection methods, including interviews; stated the duration of the research study; and provided my contact information. I explained the importance of the study and the value of participants' contributions in supporting positive social change (Creswell, 2012). At the conclusion of this meeting, I requested attendees' telephone numbers and e-mail addresses so that I could contact the science teachers by telephone and send informed consent forms to all who volunteered to participate in the study. The science teachers who volunteered as participants reviewed, signed, and returned the informed consent forms to me through e-mail.

I contacted the participants via telephone calls and e-mails to acknowledge receipt of their consent forms after they signed and returned them to me. All informed consent forms associated with the study were received by me through e-mail before data collection began. Participants were not mandated to participate and could withdraw from the study at any time.

Each participant was identified using a letter of the alphabet (i.e., Participants A, B, C, and so forth). I used these participant codes to organize and store the participant data. I protected the participants' identities by indicating the participant code on the corner of each participant's file to ensure privacy protection and confidentiality. The participants' identities were not included in the results.

As described earlier, all participants received a letter of invitation informing them of the time for their interview. In my letter, I encouraged participants to seek clarification on all matters related to the study throughout the research process. My contact information was provided to all participants so that they could contact me with any questions or concerns (Hatch, 2002). All data were confidential, and no personal data were collected. Research records will be kept in a password-protected database for 5 years upon completion of this study, and only I will have access to the records. All files will be destroyed after 5 years, when I will shred all documents and delete associated electronic files from all drives and computers.

Collection of the Data

The sources of data collection for this case study included document review and open-ended interviews (Merriam, 2009). Hatch (2002) asserted that document review and interviews are among the primary methods of collecting and analyzing data in qualitative research. The two data sources were chosen for this qualitative case study because they aligned with the conceptual framework, the problem, and the research questions.

Approval was obtained from the Institutional Review Board (IRB) through Walden University to conduct this research. After obtaining IRB approval (Approval No. 03-29-18-0325036) and the consent letter of cooperation, I presented the approval letter to the southeastern school district director. I informed the school principal that data collection might be completed in 3 to 5 weeks and would not disrupt students' learning.

After gaining approval from the research study site and securing participants' e-mail addresses, I sent an invitation letter via e-mail to the participants selected for the study.

All of the participants received a letter of invitation that introduced the research study, described its justification, and offered an opportunity to volunteer to participate in the study. I explained the importance of the study and the value of participants' contributions in supporting positive social change. I sent informed consent forms to all of the teachers who volunteered to participate in the study. The teacher participants who volunteered for the study reviewed, signed, and returned the informed consent forms to me. I contacted the participants via telephone calls and e-mails to acknowledge receipt of their consent forms after they signed and returned them to me. All informed consent forms associated with the study were received by me through e-mail before data collection began.

Participants were contacted via telephone and e-mail to set up a time for the interview. I began conducting the interviews as soon as the schedule, venue, and times were confirmed with the participants in the study. The interviews were conducted after school hours. All teacher participants in the study requested not to be audio recorded during the interviews. Each of the participants in the study declined the use of audio recorder to record their interviews; therefore, I took written notes on all participants' responses or statements. The interview data collected for the study, including signed consent forms and teachers' lesson plans obtained from the participants, will be kept confidential in a secure cabinet for a 5-year period.

Documents

The first set of data collected in this project study consisted of teachers' weekly lesson plans, which I reviewed as one of two sources of data. I scheduled a time to meet with each participating teacher and requested that each teacher submit two weekly lesson plans at least 2 weeks before the scheduled interview. I explained to each participant that I was looking for items in the weekly lesson plans that documented how teachers integrated technologies into their classroom teaching and learning in the STEM curriculum.

I developed a document review checklist (see Appendix B) to assist in the analysis of teachers' lesson plans. The checklist was based on the three components of TPACK model and included a space for notes. I created the document review checklist using the recommendations of Yin (2009). The document review checklist helped me determine how participants used technology in their classroom teaching.

Interviews

I conducted open-ended and face-to-face interviews with teachers to identify how they effectively implemented technology integration in their classroom teaching in STEM curriculum and their technology, pedagogy, and STEM content knowledge. Open-ended questions and face-to-face interviews allowed the STEM teachers to express their experiences during the interviews.

Merriam (2009) posited that an interview was needed to understand past events that cannot be replicated. An interview protocol related to the TPACK framework to answer the research questions was developed before the interview process. According to

Doody and Noonan (2013), a semistructured interview is a qualitative method of inquiry with participants that combined a predetermined set of open questions during the interview process. The semistructured interview prompted discussion with the participants and provided an opportunity for me to explore particular themes or further responses in the study. Hatch (2002) asserted that semistructured interviews enables the researcher to "create and ask additional questions" of the participants to gain depth and richness of the data.

During the interviews, each of the participants in the study declined the use of audio recorder to record their interviews; therefore, I took written notes on all participants' responses or statements. After writing down each of the participants' interviews, I used member checking for the participants to check the findings for accuracy of their data. The member checking was done for the participants to correct any type of miscommunications during the interviews, address transcription errors, additions, and/or deletions (Hagans, Dobrow, & Chafe, 2009). All the 12 teacher participants checked the interview findings for accuracy of their data and returned the interview transcript to me without correction. All the participants replied that they were satisfied with my written interview statements as accurate information.

The interviews were scheduled during the week from Monday to Friday after school hours to avoid interruption of students' learning at the study site. Upon the school principal's approval to conduct the study at the school site, the interview sessions were held at the school conference room. A sign was posted outside the designated conference room stating that an interview was in progress and do not disturb. The interviews were conducted for a period of 5 days at the project study site where the participants worked. On the first day of the interviews, three participants were interviewed. On the second day of the interviews, two participants were interviewed. On the third day of the interviews, three participants were interviewed. On the fourth day of the interviews, two participants were interviewed. On the fifth day of the interviews, two participants were interviewed. A formal interview with each participant lasted between 45 minutes and 60 minutes. The participants in the study were interviewed once.

During the interviews, I respectfully greeted the participants and addressed them with regards. I avoided using demeaning words or attitudes to address the participants in the study (Creswell, 2012). I avoided biased assumptions and awkward use of language that implied bias due to gender, sexual orientation, racial or ethnic group, religion affiliation, age or disability (Creswell, 2012). I avoided awkward use of language and made sure that I chose my words carefully while addressing the participants. I did not imply personal opinion when asking interview questions to eliminate bias (Merriam, 2009). I reiterated to the participants that the interviews are voluntary and they can decline to participate for the interview at any time. While the participants answered questions based on the interview prompts, I inserted probing and follow-up questions as necessary. The participants were informed that their written responses or statements taken during the interview were kept confidential. I thanked each participant for participating in the interview process prior to their exit.

Data Analysis

In this qualitative bounded case study, I used Hatch's (2002) typological analysis model to analyze the collected study data. I used typological analysis to analyze teachers' technology knowledge, content, and pedagogy. A typological analysis is the most appropriate method because it is a "classification system in which predetermined categories" are used to answer the research questions (Hatch, 2002). The purpose of this bounded qualitative case study was to examine how teachers integrated technology in their classroom teaching to improve students' learning outcomes in science. Technology knowledge, pedagogy knowledge, and content knowledge from TPACK framework served as the three typologies or categories to sort and code data. The documents (lesson plans) provided by the participants in the study was the first data source examined for patterns and relationships with the typologies. The interview data is the second data source examined for patterns and relationships with the typologies. These two data sources (documents and interviews) were examined for examples that support the emerging patterns and examples that contradict or invalidate the patterns identified. The relationships among the emerging patterns were identified and generalizations were made. The raw data were examined for the information which supported and contradicted the generalization that was made. Therefore, typological analysis served as the one method of data analysis used for this study.

Typological Analysis

This qualitative bounded case study used Hatch's (2002) model to illustrate the typologies in analyzing data. Hatch (2002) posited that typologies are predetermined categories or codes used to answer the research questions. The categories or codes are identified before data were analyzed. Technology knowledge, content knowledge, and pedagogy knowledge from TPACK framework (Lee & Kim, 2014) served as the predetermined codes for the typological analysis of the data collected in this study. Technology knowledge, content knowledge, and pedagogy knowledge are approaches that are core elements of the TPACK framework and critical for teachers to effectively implement technology integration in their classroom teaching in STEM curriculum.

The teachers' technology knowledge, content, and pedagogy were examined using Hatch's (2002) model to analyze data as follows:

1. I identified data that aligned or related to each typology.
2. I read the data entries according to each typology and recorded the main ideas that come up as data was analyzed.
3. I searched for patterns and relationships among the main ideas.
4. I reread the raw data coding entries according to the patterns and relationships identified.
5. I searched the raw documents data and interviews data for excerpts supported or refuted the patterns and relationships identified.
6. I wrote generalizations that represented the patterns and relationships that was found in the data (Hatch, 2002, p. 153).

I used the typological analysis steps to read the documents data and interviews data and identified links between the data and the typologies. Then, I reread the data according to the typologies and wrote the main ideas in the data. Then, the main ideas entries were analyzed for relationships to the typologies. I identified patterns after the main ideas were supported and contradicted. Then, I wrote the generalizations based on the patterns and relationships that were found in the raw data.

Document Analysis

Documents data (lesson plans) collected from the teacher participants were analyzed to identify any related typologies. The teacher participants provided documents (lesson plans) to examine how they integrated technology in their classroom teaching to improve students' learning outcomes in STEM curriculum. I collected 24 weekly lesson plans (Appendix B) from the 12 STEM teachers. I used Hatch's typology (2002) analysis to determine teachers' technology knowledge, content, and pedagogy from the documents (lesson plans). I read and highlighted the documents data entries using different colors according to each typology. After reading the documents data the first time, I carefully read the documents data three times; one time per typology. I ensured that the documents data were highlighted with a specific color that matched each typology. Then, I read entries by typology and recorded the main ideas for each typology that emerged as documents data is analyzed (See Table 3).

Table 3

Typological Analysis Step 3: Key Entries Recording Main Ideas for the Typologies (Technology Knowledge, Content Knowledge, and Pedagogy Knowledge) and Summary Statement for the Main Ideas in Document Data

Main ideas for the typologies	Summary statement for the typologies
Technology knowledge	**Technology knowledge**
Laptop computer usage	Participants used laptop computers for instruction.
Desktop computer usage	Participants used desktop computers for instruction.
Manual projector usage	Participants used outdated manual projectors for instruction.
Laptop computer carts use	Participants used laptop computer carts for instruction.
Internet	Participants integrated the Internet for science instruction.
Downloading video clips	Participants integrated video clips for science instruction.
Use of Google platform	Participants integrated Google site for science instruction.
Use of YouTube video clips	Participants integrated YouTube video clips for science instruction.
Online formative assessment use	Participants integrated online formative assessment in science instruction.
Online summative assessment use	Participants integrated online summative assessment in science instruction.
Online instructional differentiation	Participants integrated online instructional differentiation in science.
Posting on social networks	Participants integrated social networks such as Edmondo to post assignments in science instruction.
Content knowledge	**Content knowledge**
Used blended learning	Participants used blended learning as a strategy to teach content vocabulary.
Used web-based lessons to teach content vocabulary	Participants used web-based lessons as strategy to teach content vocabulary.
Used web-quest resources	Participants used web-quest resources as a strategy to teach content vocabulary.
Used web-game resources	Participants used the web-game resources as a strategy to teach content vocabulary.
Used web-based simulations	Participants used web-based simulations as a strategy to teach content vocabulary.
Used web-based animations	Participants used web-based animations as a strategy to teach content vocabulary.
Pedagogy knowledge	**Pedagogy knowledge**
Used web-based lessons to teach content vocabulary	Participants used blended learning as a strategy to teach content vocabulary. Participants used web-based lessons as strategy to teach content vocabulary. Participants used web-quest resources as a strategy to teach content vocabulary. Participants used the web-game resources as a strategy to teach content vocabulary. Participants used web-based simulations as a strategy to teach content vocabulary. Participants used web-based animations as a strategy to teach content vocabulary.

Next, I searched for patterns and relationships among the main ideas identified in the documents data. I did not see nonexamples in the documents data. Then, using the main ideas, I examined the documents data for patterns, relationships, and themes within the typologies. I reread my coding entries within the documents data according to the patterns and relationships that was identified as a requirement for typological analysis step 3. Next, I searched the raw documents data for samples that supported or refuted the patterns and relationships identified. Next, I recorded the entries that aligned with different elements in the patterns and where these patterns are located in the documents data. Then, I coded the data entries within the documents data according to patterns identified. Table 4 contains the typologies, patterns identified and the coding for document data.

Table 4

Typological Analysis Step 5: Coding Data Entries According To Patterns Identified in the Document Data

Typologies	Patterns identified	Coding
Technology knowledge	Participants used laptop computers for instruction. Participants used desktop computers for instruction. Participants used manual projectors for instruction. Participants used laptop computer carts for instruction.	Technology use
	Participants integrated the Internet for science instruction. Participants integrated video clips for science instruction. Participants integrated Google site for science instruction. Participants integrated YouTube video clips for science instruction.	Technology integration
Content knowledge	Participants integrated online formative assessment in science instruction. Participants integrated online summative assessment in science instruction. Participants integrated online instructional differentiation in science. Participants integrated social networks such as Edmondo to post assignments in science instruction.	
Pedagogy knowledge	Participants used blended learning as a strategy to teach content vocabulary. Participants used web-based lessons as strategy to teach content vocabulary. Participants used web-quest resources as a strategy to teach content vocabulary. Participants used the web-game resources as a strategy to teach content vocabulary. Participants used web-based simulations as a strategy to teach content vocabulary. Participants used web-based animations as a strategy to teach content vocabulary.	Used web-based lessons to teach content vocabulary

Next, I decided if the patterns identified are supported by the documents data. Then, I wrote generalization sentences that represented the relationships between the patterns that was found in the documents data which served as themes (See Table 5).

Table 5

Typological Analysis Step 6: Examination of Document Data for Relationships and Patterns and One-Sentence Generalizations That Served as Temporary Themes

Themes emerged	One-sentence generalization
Technology use	Technology use in STEM classes.
Technology integration	Technology integration in science instruction.
Web-based lessons to teach content vocabulary	Using web-based lessons to teach content vocabulary in STEM classes.

Three temporary themes that emerged from the documents data: technology use in STEM classes, technology integration in science instruction, and web-based lessons used to teach content vocabulary in STEM classes. Two themes: technology use in STEM classes and technology integration in science instruction were associated with Research Question 1 (RQ1) and supported by documents data. All the three themes were associated with Research Question 2 (RQ2) and supported by documents data. There was no evidence of the discrepant cases in the documents data.

Interviews

Handwritten participants interview responses served as the interview data. The interview transcripts were examined for patterns within the typologies. The teacher participants provided interview responses to examine how they integrated technology in their classroom teaching to improve students' learning outcomes in STEM curriculum. I analyzed interview data (Appendix C) from 12 STEM teacher participants. I used Hatch's (2002) typology approach to analyze interview data (Appendix C) that aligned or related to the three typologies (technology knowledge, content knowledge, and pedagogy knowledge). I read the interview data entries according to each typology. I highlighted each typology related to the interviews data with a different color. After reading the interview data the first time, I carefully read the interviews data three times; one time per typology. I ensured that the interviews data were highlighted with a specific color that matched each typology. Then, I read entries by typology and recorded the main ideas for each typology that come up as interviews data is analyzed (See Table 6).

Table 6

Typological Analysis Step 3: Key Entries Recording Main Ideas for the Typologies (Technology Knowledge, Content Knowledge, and Pedagogy Knowledge) and Summary Statement for the Main Ideas in Interview Data

Main ideas for the typologies	Summary statement for the typologies
Technology knowledge	**Technology knowledge**
Laptop computer usage	Participants used laptop computers for instruction.
Desktop computer usage	Participants used desktop computers for instruction.
Manual projector usage	Participants used outdated manual projectors for instruction.
Laptop computer carts use	Participants used laptop computer carts for instruction.
Internet	Participants integrated the Internet for science instruction.
Downloading video clips	Participants integrated video clips for science instruction.
Use of Google platform	Participants integrated Google site for science instruction.
Use of YouTube video clips	Participants integrated YouTube video clips for science instruction.
Online formative assessment use	Participants integrated online formative assessment in science instruction.
Online summative assessment use	Participants integrated online summative assessment in science instruction.
Online instructional differentiation	Participants integrated online instructional differentiation in science.
Posting on social networks	Participants integrated social networks such as Edmondo to post assignments in science instruction.
Poor Internet connection	Participants experienced poor Internet connection as a barrier to technology integration.
Lack of access to district recommended web-based science sites	Participants lacked access to district recommended web-based science sites as a barrier to technology integration.
Lack of inteactive Smart boards	Participants lacked access to interactive Smart boards as a barrier to technology integration.
Lack of access to digital projectors	Participants lacked access to digital projectors as a barrier to technology integration.
Problem of obsolete and slow running computers	Participants has problem of obsolete and slow running computers as a barrier to technology integration.

(*table continues*)

Main ideas for the typologies	Summary statement for the typologies
Content knowledge	**Content knowledge**
Used blended learning	Participants used blended learning as a strategy to teach content vocabulary.
Used web-based lessons to teach content vocabulary	Participants used web-based lessons as strategy to teach content vocabulary.
Used web-quest resources	Participants used web-quest resources as a strategy to teach content vocabulary.
Used web-game resources	Participants used the web-game resources as a strategy to teach content vocabulary.
Used web-based simulations	Participants used web-based simulations as a strategy to teach content vocabulary.
Used web-based animations	Participants used web-based animations as a strategy to teach content vocabulary.
Pedagogy knowledge	**Pedagogy knowledge**
Used web-based lessons to teach content vocabulary	Participants used blended learning as a strategy to teach content vocabulary. Participants used web-based lessons as strategy to teach content vocabulary. Participants used web-quest resources as a strategy to teach content vocabulary. Participants used the web-game resources as a strategy to teach content vocabulary. Participants used web-based simulations as a strategy to teach content vocabulary. Participants used web-based animations as a strategy to teach content vocabulary.

Next, I searched for patterns and relationships among the main ideas identified in the interviews data. I did not see nonexamples within the interviews data. Then, I examined the interviews data for patterns, relationships, and temporary themes within the typologies. I reread the raw data coding entries within the interviews data according to the patterns and identified relationships. Next, I searched the raw interviews data for samples that supported or refuted the patterns and relationships identified. Next, I recorded the entries that aligned with different elements in the patterns and where these patterns are located in the interviews data. Then, I coded the data entries within the interviews data according to patterns identified. These are the themes (See Table 7).

Table 7

Typological Analysis Step 5: Coding Data Entries According to Patterns Identified in the Interview Data

Typologies	Patterns identified	Coding
Technology knowledge	Participants used laptop computers for instruction. Participants used desktop computers for instruction. Participants used manual projectors for instruction. Participants used laptop computer carts for instruction.	Technology use
Content knowledge	Participants integrated the Internet for science instruction. Participants integrated video clips for science instruction. Participants integrated Google site for science instruction. Participants integrated YouTube video clips for science instruction. Participants integrated online formative assessment in science instruction. Participants integrated online summative assessment in science instruction. Participants integrated online instructional differentiation in science. Participants integrated social networks such as Edmondo to post assignments in science instruction.	Technology integration
	Participants experienced poor Internet connection as a barrier to technology integration. Participants lacked access to district recommended web-based science sites as a barrier to technology integration. Participants lacked access to interactive Smart boards as a barrier to technology integration. Participants lacked access to modern digital projectors as a barrier to technology integration. Participants has problem of obsolete and slow running computers as a barrier to technology integration.	Barriers to technologyintegration
Pedagogy knowledge	Participants used blended learning as a strategy to teach content vocabulary. Participants used web-based lessons as strategy to teach content vocabulary. Participants used web-quest resources as a strategy to teach content vocabulary. Participants used the web-game resources as a strategy to teach content vocabulary. Participants used web-based simulations as a strategy to teach content vocabulary. Participants used web-based animations as a strategy to teach content vocabulary.	Used web-based lessons to teach content vocabulary

Next, I decided if the patterns identified are supported by the interviews data. Then, I wrote a generalization sentence that represented the the patterns that were found in the interviews data which served as temporary themes (See Table 8).

Table 8

Typological Analysis Step 6: Examine Interview Data for Relationships Among the Patterns and Write One-Sentence Generalizations That Served as Themes

Themes emerged	One-sentence generalization
Technology use	Technology use in STEM classes.
Technology integration	Technology integration in science instruction.
Barriers to technology integration	Barriers to technology integration in science instruction.
Web-based lessons to teach content vocabulary	Using web-based lessons to teach content vocabulary in STEM classes.

After examination of the patterns in the interview data that supported a one sentence generalization, I reviewed each highlighted section of the typologies to identify temporary themes. Next, I transferred the temporary themes to a Microsoft Excel summary sheet. Next, I added percentages of how frequent each theme occurred according to the number of times the participants answered the question during the interviews. Next, I added to the exisiting excel spread sheet the themes which occurred more frequently in each typology (see Table 9 for frequency).

Table 9

Typological Analysis Step 6: Percentages of Frequency the Themes occurred in the Interview Data

Typologies	Percentages of frequency of theme's occurrence
Technology knowledge	92%
Pedagogy knowledge	84%
Content knowledge	88%

Based on the two data sets, four themes that emerged: technology use in STEM classes, technology integration in science instruction, barriers to technology integration in science instruction, and using web-based lessons to teach content vocabulary in STEM classes. Three themes: technology use in STEM classes, technology integration in science instruction, and barriers to technology integration in science instruction were associated with Research Question 1 (RQ1) and supported by the interview data. All four themes were associated with Research Question 2 (RQ2) and supported by interview data. There was no evidence of the discrepant cases in the interviews data. The themes were as follows:

- Technology use in STEM classes
- Technology integration in science instruction
- Barriers to technology integration in science instruction
- Using web-based lessons to teach content vocabulary in STEM classes

Process by Which Data Were Gathered and Recorded

This qualitative case study examined STEM teachers' technology integration in their classroom teaching to improve students' learning outcomes. Purposeful sampling was used to identify the teacher participants based on the list of 18 teachers who would fit the study attributes. I emailed invitation letters to these 18 potential STEM teacher participants, and received responses from all 18 potential participants who agreed to participate in my study. The next week, I explained the purpose of the research and informed consent form to all the 18 potential participants. I gave a copy of the informed consemt form to each potential teacher participant and allowed them 3 days to decide whether they were willing to participate in the study.

Within 24 hours, I received e-mail messages from all 18 potential teacher participants that they volunteered to participate in the study. Of the 18 volunteered teachers, 12 participants were purposefully selected to participate in the study (Merriam, 2009). Each teacher participant reviewed, signed, and returned the informed consent forms to me through e-mail before data collection began. The qualitative questions and follow-up questions for the semistructured interview were based on the conceptual framework and related literature.

The next day, the teacher participants selected a date, time, and venue of the qualitative interview. The interviews were conducted in the conference room afterschool hours when students have left the school building. The participants were informed that their interviews would be audio-recorded, transcribed, and returned to them to check the findings for accuracy of their data (member checking). The 12 teacher participants declined to be audio-recorded during the interviews. Each interview with the teacher participants lasted between 45 minutes and 60 minutes. The participants were interviewed over a period of 5 days. The interview protocol, including follow-up questions, was used to elicit indepth responses from the particiants. When participants had difficulty responding, they were given follow-up questions such as: “Tell me more about…” “Explain what happened as a result of your decision.” “What did you learn about…?” Please give me an example of…? to continue with their responses. Follow-up questions were used to facilitate the exploration of rich descriptive data from personal discussion of their individual experiences. I wrote verbatim responses from the 12 teacher participants.

I used an assigned alphabet letter (A through L) to remove the identity of the participants. I conducted transcript review and sent the interview transcript to each teacher participant to verify the contents. All the 12 teacher participants verified and returned the interview transcript without correction. All the participants replied that they were satisfied with my written interview responses as accurate information.

Data Analysis Results

Introduction

During the analysis of data in this qualitative case study, I sorted the typological categories or codes that emerged into four themes: technology use in STEM classes, technology integration in science instruction, barriers to technology integration in science instruction, and using web-based lessons to teach content vocabulary in STEM classes. I identified these four themes that could be connected to technology knowledge, content, and pedagogy typologies.

Themes Identified in Data

I sorted the four themes identified in the data according to their relationship to the research question as well as data collection. After reviewing and coding the documents and interview transcripts, I selected excerpts from the documents and transcripts to support the emerging themes. The excerpts were verbatim responses obtained from the STEM teacher participants. Details of the four themes identified in data are as follows:

Theme 1: Technology use in STEM classes. This theme emerged from both the documents data (lesson plans) and interviews data. In the process of analyzing the information provided by the participants during the interviews, I found that all 12 teacher participants indicated they used technology in their STEM classes at the study site. Participants used laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as technology instructional tools in their STEM classrooms at the study site. Participant B stated,

> I used computer as a technology tool to access e-mails and for taking classroom attendance. I use technology for Internet connection and PowerPoint presentation in my STEM classroom. I also use technology to access the free web-based science sites that I know to improve students' learning outcomes in STEM classes.

Participant B's response about technology use in STEM classes was in agreement with the responses provided by other participants. Here is another example of a response provided by Participant E:

> I use manual projector and laptop computer for warm-up quizzes, lesson introduction, and reviews of weekly lessons in STEM classes. I use technology frequently for entering students' grades and accessing the free web-based science sites for students' learning.

Participant B and Participant E explained that they used technology in STEM classes to access the free web-based science sites which improved students' learning.

Technology use in STEM classes is aligned to Research Question 1 (RQ1) and Research Question 2 (RQ2) and supported by both the documents data (lesson plans) and interviews data. This theme is supported by other research literature regarding how STEM teachers use technology resources for effective classroom instruction which makes 21st-century learning possible (Sadaf, Newby, & Ertmer, 2016). Waters, Kenna, and Bruce (2016) posited that the inclusion of technology use is an essential feature for effective classroom instruction in district schools. According to Waters et al.'s study, technology resources include computers, mobile devices, social media platforms and networks, software applications, and the Internet which were used by STEM teachers in this study.

Theme 2: Technology integration in science instruction. This theme emerged from both the documents data (lesson plans) and interviews data. The information provided by the participants in the study revealed that they integrated technology to improve students' learning in science instruction. Participants integrated technology tools by downloading science video clips from the Internet and using the google.com for science instruction to improve students' learning outcomes. Participants integrated technology by using YouTube site to access instructional videos for science instruction. Participants integrated technology by providing online formative assessments and online summative assessments for students' learning in science instruction. Participants also integrated technology by providing online instructional differentiation for students' learning in science instruction. The online instructional differentiation enables the students to work on different science assignments using different websites.

For example, Participant A responded as follows:

> I integrated technology by downloading science video clips from different websites and google.com for science instruction to improve students' learning. I integrated technology using the YouTube site to access instructional videos to enhance science instruction. Youtube instructional video clips and materials from other science websites helps my students as visual to improve their knowledge in completing assignments in STEM classes.

Participant J reported,

> I integrated technology by using online resources such as the USA Test Prep and biology4kids.com in science instruction. I integrated the USA Test Prep and Biology4Kids website as technology tools to access sample test materials for my students to practice and improve their test-taking skills in STEM classes.

Participant H further reported,

> I integrated technology using the USA Test Prep in my STEM classes because it assists in simplifying teaching and learning. I integrated technology using the USA Test Prep to give online formative assessment tests and online summative

> assessment tests for my students in STEM classes. The USA Test Prep assessment tests helps my students to learn science content and improve their test-taking strategies in STEM classes. I also integrated technology using the USA Test Prep as an online tool for instructional differentiation to improve students' learning. The USA Test Prep online helps my struggling students to work on their areas of academic need or deficiency in science while other students who are proficient in science content work on the assigned task in STEM classes.

Participants expressed agreement that technology integration positively enhanced students' learning outcomes in science instruction. Technology integration in science instruction is aligned to Research Question 1 (RQ1) and Research Question 2 (RQ2) and supported by both the documents data (lesson plans) and the interviews data. This theme is supported by research literature regarding how science teachers depend on implementing effective technology integration as a measure to reform their instructional practices in the classroom setting (Farisi, 2016). Hsu (2016) asserted that implementing effective technology integration has the potential to reform classroom instructional practices in district schools. According to Hsu, integrating technology tools such as social networks by downloading science video clips from the Internet, using the google.com, and YouTube site to access instructional videos for science instruction, which was used by science teachers in this study, helps to improve students' learning outcomes.

Theme 3: Barriers to technology integration in science instruction. This theme is present in the interviews data only. The most common barriers identified by the teacher participants in science instruction were poor Internet connection, lack of access to district recommended web-based science sites, lack of interactive Smart boards, lack of digital projectors, and problem of obsolete and slow-running computers. For example, Participant C reported,

> Our technology integration in STEM classes is hindered by poor Internet access. We have a computer laboratory in STEM classes but it is not monitored. We do not have access to the district recommended web-based sites for technology integration in science instruction. If teachers have access to district recommended web-based science sites and some of the available free web-based science resources, it will help our students to learn and understand science content much better.

Participants were asked to provide information pertaining to the barriers that hindered their technology integration. Participants B, D, F, K, L, and G further stated,

> Sometimes, we have problem of obsolete and slow running computers which hinders our technology integration in science instruction. We do not have any interactive Smart boards and digital projectors for technology integration in science instruction. We need professional development training on how to use the interactive Smart boards and digital projectors in STEM classes.

Findings from the interviews data revealed that participants expressed agreement that barriers to technology integration in science instruction hindered them from effectively implementing technology in their STEM classes. Barriers to technology integration in science instruction is aligned to Research Question 1 (RQ1) and Research Question 2 (RQ2) and supported by the interviews data only. This theme is supported by research. It is imperative for district schools to ensure science teachers and students experience success using technology by eliminating barriers impeding the implementation of technology in the classroom setting (Banas & Polly, 2016). Ruggierro and Mong (2015) asserted that it is imperative for educators to eliminate barriers impeding the implementation of technology integration in classroom instruction so that schools can make sufficient students' academic gain. According to the research literature, poor Internet connection, lack of interactive Smart boards, lack of digital projectors, and problems with obsolete and slow-running computers constituted the common barriers impeding technology implementation in the classroom setting (Gonczi, Maeng, Bell, & Whitworth, 2016; Karaoglan, Fatma, Yilmaz, Ozturk, Sezer, & Karademir, 2015; Pittman & Gaines, 2015). Carver (2016) supported this assertion and posited that it is imperative to address these barriers impeding the implementation of technology integration in teacher instructional practices to achieve the benefits of technology use to improve teaching and learning in K-12 schools. Participants poor Internet connection, lack of access to district recommended web-based science sites, lack of interactive Smart boards, lack of digital projectors, and obsolete and slow-running computers are the common barriers at the study site.

Theme 4: Using web-based lessons to teach content vocabulary in STEM classes. This theme is present in both the documents data (lesson plans) and interviews data. Documents data (lesson plans) and interviews data (transcripts) revealed the teacher participants identified blended learning, web-quest resources, web-game resources, web-based simulations, and web-based animations as web-based lessons that helped them to teach content vocabulary in STEM classes. One of the web-based lessons identified in the interviews by the teacher participants was using the "Google" platform (www.google.com) to teach content vocabulary in STEM classes. Participant B declared,

> Web-based lessons made it easier to teach and learn content vocabulary in STEM classes. I direct my students to access and connect to www.google.comon the Internet and look up unfamiliar science content vocabulary words. My students discovered that it is easier to look up and learn the science content vocabulary on "Google" than using the dictionary.

The participants expressed agreement that incorporating web-based lessons was an important aspect of teaching content vocabulary in STEM classes. The participants agreed that utilizing the social media, web-based simulations, and web-based animations to teach content vocabulary in STEM classes empowered the students to collaborate effectively in classroom activities. Participant A stated,

> I used web-based lessons by accessing cellsalive.com which helps my students to multi-task in my STEM class. My students used the cellsalive.com to compare the textbook materials to the web-based materials which made it simple to teach content vocabulary in STEM classes. Cells Alive website made it easier for me to teach content vocabulary. Cells Alive website made it easier for my students to learn and understand science simulations as visual in connection to the textbook materials in STEM classes. Students collaborate with each other using the science vocabulary words they wrote on the index card and finding the meaning on "Google" which made it easier to teach content vocabulary in STEM classes.

Participants C, H, and E further explained,

> We used web-based animations by accessing brainpop.com to teach content vocabulary in STEM classes. Brain POP website provides animated science interactives for our students and helps them to learn content vocabulary in STEM classes. We used Brain POP website as a web-based technology tool into our lesson activities to enhance teaching content vocabulary in STEM classes.

Findings from the documents data (lesson plans) and interviews data revealed the teacher participants were in agreement that using web-based lessons helped them to teach content vocabulary in STEM classes. Using web-based lessons to teach content vocabulary in STEM classes is aligned to Research Question 1 (RQ1) and Research Question 2 (RQ2) and supported by both the documents data (lesson plans) and the interviews data. This theme is supported by research that science teachers incorporate the web-based instructional technology tools in their lessons to enhance student engagement and knowledge during classroom activities (NSTA, 2015). According to the NSTA, science teachers are expected to use educational technology such as the web-based lessons to deliver effective pedagogical instruction in science classrooms. In further support of this theme, NSTA (2015) posited that it is imperative for science teachers to integrate technology effectively in science classroom and use web-based lessons necessary to support students' learning in schools.

Evidence of Quality

In this qualitative case study, after data were analyzed, I used triangulation, rich descriptions of data, member checking, and peer debriefer to ascertain quality, credibility, and reliability (Merriam, 2009). Merriam posited that triangulation uses many different sources as evidence to improve quality of data in qualitative research. The triangulation technique validates data through cross verification from analyzed data. According to Merriam, triangulation of the data made it possible for the elimination of disparate information without grounds for comparison to ascertain data integrity. Triangulation method made it possible for me as the researcher to corroborate data collected from the document review and the interviews. Therefore, I corroborated the findings from the document review of teachers' lesson plan with the interviews to strengthen data quality.

I used rich descriptions of data to ascertain quality, credibility, and reliability (Merriam, 2009). Using rich description of details has been "a principal strategy" for evidence of data quality (Creswell, 2012; Merriam, 2009). Rich descriptions of data enables readers to see themselves in particular situation as participants thereby making the findings more realistic to the reader (Creswell, 2012). According to Creswell, detailed descriptions of the setting, participants, and interactions among the participants enables readers to reason with the findings. Creswell maintained that detailed descriptions of the setting enables readers to estimate how close their situations aligns with that of the participants in comparison to their similar situations. Merriam (2009) posited that rich, thick descriptions of data are necessary to contextualize the study so that readers can determine whether their situations match the research context, and also whether the findings can be transferred (p. 229).

As the researcher, I used member checks to ensure that there was no bias in data collection as posited by other researchers (Davies, 2011; Glesne, 2011; Hancock &

Algozzine, 2011; Merriam, 2009; Patton, 2002; Yin, 2009). Member checking requires me to return the findings to the participants for them to check the findings for accuracy of their data, and then the participants returning the findings to me with their feedback. Member checks helps to validate the information and/or data to ensure accuracy and eliminate researcher bias. Yin (2009) posited that member check is a draft review to corroborate evidence presented in qualitative case study (p. 182). I sent a two-page summary of the findings via email to participants after data were analyzed. The participants were instructed to check the findings for accuracy of their data. Participants had 7 days to complete member checks and inform me by returning the transcripts back with feedback whether the findings were an accurate representation of their data. Participants completed member checks and informed me that there was no discrepancies between my findings and their feedback. Therefore, I was not required to adjust my data findings.

I asked one of my colleague who completed doctorate degree (PhD) to be a "peer debriefer" (Merriam, 2009, p. 229). Peer debriefing helped to exclude extraneous information from the data findings (Merriam, 2009). Peer debriefing was completed within a period of 3 days (Merriam, 2009). My colleague reviewed the findings from the data collection including cross referencing the themes and interpretation of findings extracted from the data. My peer debriefer gave more insight in the data findings as well as feedback on the data analysis of themes.

Summary of the Findings/Outcomes

This qualitative case study examined how teachers integrated technology in their classroom teaching to improve students' learning outcomes in science. Understanding how teachers integrated technology were framed through the conceptual framework from Lee and Kim (2014) as well as two guiding research questions, using a bounded qualitative case study design (Merriam, 2009). This research study addressed the specific problem of how high school teachers in a southeastern U.S. school district integrated technology in their classroom teaching in STEM curriculum to improve students' learning outcomes.

The results of this study indicated a need for PD training program addressing how to implement technology in STEM classes with an emphasis on teaching technology, pedagogy, as well as content knowledge in southeastern school district. The teacher participants expressed concerns about barriers they experienced effectively implementing technology in STEM classes during the interviews. The results of this study revealed that these teachers were integrating technology to teach STEM content, however, they were hindered by the common barriers to effectively implement technology integration into their teaching in STEM classes. As a result of the common barriers hindering the participants from integrating technology, a need exists for new PD training for teachers. The PD training will serve as an intervention and remedy to resolve participants' concerns in this bounded qualitative case study.

As part of the Every Student Succeeds Act (ESSA, 2015), federal government regulations (Title IV A) require educators to have the skills needed to use technology in classroom instruction. According to ESSA, implementing technology in classroom instruction would enhance teaching and learning in all subject areas. ESSA recommended that providing/creating a PD would enable the teachers to facilitate quality classroom instruction to improve students' optimal learning outcomes. In support of this notion, Baser, Ozden, and Karaarsian (2017) asserted that one of the challenges to technology integration is providing teachers with the knowledge to infuse technology into the curriculum (p. 132). During the interviews, some of the teacher participants expressed desire for PD opportunities to integrate technology in their classroom teaching. These teacher participants indicated that more PD opportunities would assist them to acquire additional knowledge and resolve barriers hindering their classroom technology use. Based on the concerns expressed by the teacher participants in this study, there is a need that exists for the creation of new PD training for teachers to effectively implement technology in STEM curriculum. Section 3 provides additional details for the proposed teacher PD and implementation strategies.

Conclusion

Documents review of teachers' lesson plans and interviews were important for creating an understanding of how teachers integrated technology in their classroom teaching to improve students' learning outcomes. The data analysis process included examining data from both participant lesson plans and interviews. In this study, teachers demonstrated competencies related to content knowledge, which is important for effectively implementing technology into their teaching in STEM classes to improve students' learning outcomes. The data analysis process allowed a total of 4 themes to emerge.

Section 3: The Project

The Project

Introduction

The project outcome of this study is a PD training on using the TPACK instructional practices and available technology instructional tools in STEM classes. The training will be a 3-day campus-based PD for STEM teachers who teach chemistry. In this bounded qualitative case study, I explored how the teacher participants used TPACK instructional practices and technology in STEM classes. Data on the 12 teacher participants' experiences and how they integrated technology were gathered through document review of teachers' lesson plans and semistructured interviews. The findings indicated that STEM teachers were not implementing technology effectively in their classroom teaching to improve student learning outcomes. Data findings indicated that teacher participants would benefit from PD to provide them with more tools and strategies to improve their instructional practices in STEM classes. In addition, the details from the literature review assisted in guiding the strategies that I used in the project's development. I explain in detail how the instructional practices of STEM teachers could be improved with the support of the PD training.

Appendix A details the project I designed, represented in a 3-day campus-based PD training on using TPACK instructional practices and the available technology instructional tools in STEM classes to teach chemistry lessons on various science curricular content topics. This PD will serve as an intervention to address the participants' weaknesses and/or deficiencies in implementing technology effectively in STEM classes.

Purpose, Goals, Learning Outcomes, and Target Audience

Purpose of This Project

The purpose of this PD project is to train teachers on how to use TPACK instructional practices and available computers with manual projectors as technology instructional tools in STEM classes to plan and teach chemistry lessons on various science curricular content topics. The intention of the PD is to provide specific training to assist STEM teachers in their classrooms to enhance their use of technology and better meet students' learning outcomes. Chemistry will be used as the content for this project.

Goals of The PD

The five measurable goals of the PD are as follows:

1. Increase teachers' understanding of using technology to teach chemistry.
2. Increase teachers' frequency of using technology to teach chemistry.
3. Increase teachers' effectiveness in using technology to teach chemistry.
4. Increase teachers' collaboration to plan with peers using technology to teach chemistry.
5. Increase teachers' performance to differentiate instruction using technology to teach chemistry.

Increasing teachers' understanding of using technology to teach chemistry (*Goal 1*). According to the researchers, PD helps teachers increase technology use to enhance student learning in the classroom setting (Ale et al., 2017; Al-Harthi et al., 2018; Scherer et al., 2018). Increasing teachers' frequency of using technology to teach chemistry is important to support students' learning and increase achievement levels (*Goal 2*). Training teachers to implement technology integration is important in the classroom with varying frequencies (Crowley, 2017; Koh et al., 2015; Murthy et al., 2015; Zelenak, 2015). Increasing teachers' effectiveness in using technology to teach chemistry is important to determine if they learned the skills (*Goal 3*). Teachers are effective using technology after they learn the skills to deliver instruction, which is significant in the classroom setting to improve teaching and learning outcomes (Al-Balushi & Al-Abdali, 2015; Al Musawi et al., 2015; Naizer et al., 2017; Valdmann et al., 2017). Increasing teachers' collaboration to plan with peers using technology to teach chemistry is needed for instructional planning in the classroom setting to support students' learning outcomes (*Goal 4*). Team collaboration for instructional planning assists teachers in planning how to use technology in the classroom setting to support students' learning outcomes (Baser et al., 2017; Burrell et al., 2015; Dorner & Kumar, 2016; Kempen & Steyn, 2017; Shih-Hsung et al., 2015). Increasing teachers' performance to differentiate instruction using technology to teach chemistry is important for differentiating instruction to assist teachers in supporting struggling students in the classroom setting (*Goal 5*). Instructional differentiation assists teachers to deliver classroom instruction to students on varying academic levels (Banas & Polly, 2016; Bozkurt & Ruthven, 2017; DePountis et al., 2015; Lin et al., 2015; Sparapaqni & Calahan, 2015). Teachers' attainment of these PD goals will be measured using a Likert scale (see Appendix A). To achieve these PD goals, I concluded that a 3-day campus-based PD training would provide adequate assistance to the teacher participants to improve their technology integration and/or instructional practices in STEM curriculum.

Learning Outcomes of The PD

STEM PD is designed to address one of the goals on each full day of the 3-day campus-based PD sessions identified in this project. The learning outcomes of this project are as follows:

Upon successful completion of PD Day 1, the teacher participants will

- Use the TPACK instructional practices in STEM classes to plan and teach a chemistry lesson on periodic table of the elements (Group 1 through Group 18) and identify the number of electron charges in each group, excluding transition metals (Group 3 through Group 12), as well as identify the number of valence electrons in each element in the groups with available technology instructional tools.

Upon successful completion of PD Day 2, the teacher participants will

- Use the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as technology instructional tools in STEM classes to plan and teach a chemistry lesson on other periodic trends from the periodic table to explain the relative properties of elements based on patterns of atomic structure.

Upon successful completion of PD Day 3, the teacher participants will

- Use the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as technology instructional tools in STEM classes to plan and teach a chemistry lesson on atomic structure from the periodic table of the elements using electron cloud and carbon as the element to identify the number of electrons in each energy level.

Target Audience for This Project

The target audience for this PD project is science teachers who have direct duties and responsibilities for delivering content material to students in STEM classes at the urban high school selected as the study site. Each of the teacher participants has over 6 years of experience teaching in secondary education. All the teacher participants hold a Bachelor of Science degree.

Rationale

Project Content Rationale

The project was chosen because the literature review in Section 1 revealed that science education is lagging behind other subject areas in technology integration. Science teachers lack proper PD to increase the knowledge and skills necessary for effectively implementing technology into their teaching in STEM classes.

Data analysis documented in Section 2 of this case study indicated that the teachers were not using instructional technology effectively for several reasons: lack of knowledge to teach STEM classes using the available instructional technology tools, limited coordination of technology use, and limited knowledge on how to implement technology integration into their classroom teaching in the STEM curriculum. Carver (2016) identified several barriers encountered by teachers during technology use. Lack of effective PD and limited access to technology were the barriers that hindered teachers from using technology (Carver, 2016, p. 112). The literature identified other barriers as obsolete and slow-running computers, hardware problems, and technology integration skills that hindered teachers from using technology effectively (Broad, 2015, p. 17). The teachers agreed that integrating technology into their classroom teaching was hindered by the common barriers identified in the data analysis.

The project addresses the problem statement in various ways. The general problem associated with technology integration impeded teachers' delivery of effective instruction in science classrooms. Teachers did not integrate technology effectively in their classroom teaching to improve students' learning outcomes in science. Data collection indicated that implementing technology effectively has a positive interaction with classroom teaching in the STEM curriculum. Using a facilitator in designing PD would be an effective way to educate teachers on how to effectively teach chemistry lessons using technology as an instructional tool in STEM classes. The study problem is addressed through 3-day PD campus-based sessions where teachers are divided into collaborative groups to plan and teach chemistry lessons on the periodic table of the elements with technology using TPACK instructional practices in STEM classes. This project is expected to help the teacher participants to better implement technology into their classroom teaching in the STEM curriculum.

Project Genre Rationale

The project genre was chosen based on the findings from the data collected during the study. The literature review in Section 1 revealed that science education is lagging behind other subject areas in technology integration. In this study, it was discovered that

STEM teachers did not receive appropriate PD to increase the knowledge and skills necessary for implementing technology effectively into their classroom teaching in the STEM curriculum. Findings revealed the need for an intervention through PD to address how to integrate technology effectively in STEM classes. This PD has been designed to train teachers on how to use TPACK instructional practices and available instructional technology tools in STEM classes to plan and teach chemistry lessons on the periodic table of the elements in their lesson plans.

I created a PD for teachers to improve the teacher participants' use of TPACK instructional practices and technology instructional tools to support students in the classroom setting. Allowing the teacher participants time to gain knowledge on how to incorporate technology into their classroom teaching during the PD may assist them in meeting the content-specific needs of students in the STEM curriculum. Jen, Yeh, Hsu, Wu, and Chen (2016) posited that PD designed with the TPACK model is effective in exploring a standard-setting method using an evidence-based approach to cross-validate teachers' ranks of proficiency levels in classroom instruction. The PD allows the teacher participants time to meet with their colleagues to share and gain additional knowledge on their instructional practices using instructional technology web-based science resources and other modern technologies available in the STEM curriculum.

Similarly, Harvey and Caro (2017) posited that PD designed with the TPACK model is important in developing and assessing teachers' classroom skills. Harvey and Carol maintained that PD can be designed with the TPACK model as a metric for measuring teachers' skills for integrating technology into their classroom instruction. In support of this notion, Al-Harthi, Campbell, and Karimi (2018) posited that the TPACK model is an effective approach to validate teachers' cloud-based learning designs in virtual learning environments. The data analysis results indicated that a variety of modern educational technology tools are available for implementing technology in STEM instruction when teachers receive adequate PD. Similarly, Jongwon, Youngmin, Young-shin, Jongseok, and Jin-su (2015) designed professional development using application of the practical on-site cooperation model (POCOM) for improving science teaching in secondary schools to assist teachers in meeting the content-specific needs of students in the STEM curriculum. This PD provided training and information to support the teacher participants with implementing technology effectively into their teaching in STEM curriculum. Therefore, PD designed with the TPACK model is aligned with the results of the data analysis in this study.

Review of the Literature

The review of the literature supported the PD for STEM teachers' classroom instructional practices and strategies to improve students' learning outcomes. The specific genre of this project was chosen based on the data gathered and recorded from the teacher participants' responses during the interviews. Based on the data coding and emerging themes, it was evident that the teacher participants' instructional practices were not properly implemented in STEM classes to improve students' learning outcomes. PD was created for the teacher participants to develop the skills needed to address their instructional practices and strategies to improve students' learning outcomes in STEM classes. This literature review addresses PD designed with the TPACK model and its benefits on teachers' instructional practices and strategies in their classroom teaching in the STEM curriculum. Data collected from the interviews indicated that the teacher participants experienced barriers in their classroom teaching, including lack of adequate training and difficulty with available technology resources in STEM classes. PD was designed with these barriers in mind to resolve concerns expressed by the teacher participants during the study.

To demonstrate saturation of the topic, I gathered materials from Walden University's online database. The saturation of the literature review was reached after researching peer-reviewed journals in education databases. I searched databases that included Educational Research Complete, ERIC, SAGE Premier, ProQuest Central, Science Direct, and Academic Search Complete. I also performed Boolean searches that included, but were not limited to, the following terms: *benefits of professional development on TPACK instructional practices, benefits of professional development on instructional technology use,* and *benefits of professional development on students' learning.*

Benefits of Professional Development on TPACK Instructional Practices

The teacher participants in the study expressed the desire for an intervention offered through professional development to improve classroom instruction in their teaching using the TPACK instructional practices. Although the teacher participants have knowledge of technology, content, and pedagogy; professional development is necessary because they were not implementing adequate instructional practices and strategies in their classroom teaching to improve students' learning outcomes in STEM curriculum.

Literature indicated that teachers' perspectives on technology use in the classroom have influenced their instructional methods and practices in technology-enabled environments (Crompton, Olszwski, & Bielefeidt, 2016). Yurtseven and Altun (2017) concurred and asserted that the connection between efficient professional development programs, enhancements of teaching skills, and students' academic achievement were important in determining the effectiveness of the professional development programs. Designing effective professional development using the TPACK model could be the basis for preparing the teachers' knowledge in the field of pedagogy.

Professional development is designed to play an important role in addressing the weaknesses expressed by the teacher participants during the interviews. The design of the professional development activity can provide solutions on how to resolve the barriers hindering the teacher participants in their classroom teaching. Bozkurt and Ruthven (2017) asserted that teachers benefit from effective professional development programs that are collaborative and supportive in nature to improve the quality of teaching and learning in the classroom setting. Designing an effective professional development could be an action that helps ensure the teacher participants are more productive and student learning is improved.

Providing effective professional development for educators cannot be restricted to science content alone. For example, Ale, Loh, and Chib (2017) asserted that professional development must include training on how to use technology tools and devices to enhance students' learning in all subject areas. Owens (2015) concurred and posited that designing an effective professional development program based on the participants' instructional practices would increase their success and stimulate their pedagogy experiences. In addition, Kempen and Steyn (2017) argued that effective professional development motivates teachers in goal setting thereby providing them an opportunity to reflect on their pedagogy experiences. Therefore, providing the teacher participants effective professional development would assist them to be competent in their classroom teaching and improve their pedagogical knowledge in the classroom setting.

Professional development benefits teachers using the TPACK instructional practices in their classroom teaching because it served as an intervention to resolve the teacher participants' concernsparticipants'concerns on common barriers to properly facilitate instruction in STEM classes. Jen et al. (2016) argued that professional development served as an intervention for preparing teachers to improve their classroom teaching and learning. In support of this notion, Karatas, Tunc, Yilmaz, and Karaci (2017) concurred, positing that professional development served as the connection between the teachers' knowledge and their classroom instructional practices to improve students' learning. Professional development is used as an intervention because it assesses the teacher participants' level of growth to properly improve their classroom teaching and students' learning outcomes.

Similarly, Yeh, Lin, Hsu, Wu, and Hwang (2015) posited that professional development was used to help teachers implement, describe, as well as document their technology use and teaching skills. According to Yeh et al., professional development helped teachers' instructional practices in evaluating and implementing effective classroom teaching. In this bounded qualitative study, professional development is used to help teachers manage their instructional delivery methods in the classroom. Researchers asserted that professional development benefits teachers in designing instructional practices necessary to improve students' learning outcomes in the classroom setting (Al-Harthi, Campbell, & Karimi, 2018; Cengiz, 2015; Scherer, Tondeur, Siddiq, & Baran, 2018; Yeh, Lin, Hsu, Wu, & Hwang, 2015; Yenmez & Ozpinar, 2017). Professional development enables teachers to establish stability between technology, content, and pedagogical knowledge in facilitating their instructional delivery in STEM curriculum.

Affirming the quality of research in professional development, researchers asserted that teachers should utilize professional development as a resource for improving instructional practices and strategies in the classroom setting (Canbazoglu, Guzey, & Yamak, 2016; Saltan, 2017; Scherer, Tondeur, & Siddiq, 2017; Suryawati & Linggasari, 2017; Urbina & Polly, 2017). These researchers also maintained that effective professional development was instrumental in building teachers' competency in their classroom teaching. In support of this notion, Al-Harthi, Campbell, and Karimi (2018) posited that effective professional development helped teachers to increase their classroom targets of delivering successful instruction to improve teaching and learning outcomes.

Benefits of Professional Development on Instructional Technology Use

Using a Professional development is an effective method for training teachers to use technology for STEM instruction to enhance students' optimal learning outcomes. Professional development helps teachers learn about using instructional technology so that they can facilitate students' learning via online and electronic media including face-to-face teaching to enhance instruction. For instance, Gonczi, Maeng, Bell, and Whitworth (2016) asserted that professional development assisted teachers to use technology as an instructional tool in planning their lessons for meaningful delivery of instruction in the classroom. In support of this notion, researchers asserted that professional development is a resource which educates teachers on how to infuse instructional technology in their classroom teaching to improve students' learning outcomes (Edwards & Nuttall, 2015; Instefjord & Munthe, 2016; Kannan & Narayanan, 2015; Kriek & Coetzee, 2016; Riordain, Johnston, & Walshe, 2016). These researchers did not focus on STEM curriculum, however, they focused on effective technology integration in the classroom setting that can improve teaching and learning in any subject areas. Professional development infused with instructional technology as an approach and strategy can positively influence teachers to improve their classroom teaching. For example, Riordain, Johnston, and Walshe (2016) posited that professional development assisted district schools across United States in providing adequate training for their teachers to transition from face-to-face instruction to online instructional technology approach in the classroom setting. Professional development can help teachers provide meaningful classroom instruction to their students irrespective of the barriers that may confront them during the transition from face-to-face instruction to online instructional technology approach.

Professional development can provide teachers the opportunity to learn new approaches and more effectively incorporate technology in their teaching in STEM classes. For example, Al-Balushi and Al-Abdal (2015) contended that professional development is more effective when using a Moodle-based professional development program to train science teachers. Al-Balushi and Al-Abdal maintained that professional development enabled teachers to teach students with creativity and demonstrate the effectiveness of the professional development they received through proper use of instructional technology approach.

Benefits of Professional Development on Students' Learning

Students' learning is a learner focused education which shifts the instructional focus from the teacher to the students in the classroom setting (Kriek & Coetzee, 2016). According to Kriek and Coetzee, when teachers facilitate instruction in the classroom, students' interest in teaching and learning becomes the primary focus of instruction and classroom activities. Professional development is an integral part of teaching and learning that supports students' learning. Professional development focuses on helping the teacher participants develop the skills necessary to facilitate students' learning in the classroom setting. For example, Kriek and Coetzee (2016) posited that focusing on students' learning as part of the professional development is instrumental in capturing teachers' comprehension and knowledge to plan classroom activities geared towards successful students' learning outcomes. Edwards and Nuttall (2015) concurred, positing that professional development helped to train teachers to focus on students' learning through effective instructional strategies that supported their pedagogical knowledge in the classroom setting. Concerns expressed by the teacher participants during the interviews placed students' learning as the principal focus of classroom instruction which shifts teaching and learning from the teacher to the student.

Researchers asserted that professional development can benefit students' learning as a primary focus for instructional practice which has been correlated to the teachers' instructional delivery and approach in the classroom setting (Kempen & Steyn, 2017; Overstreet, 2017; Phelps, Kelcey, Jones, & Liu, 2016; Trumper & Eldar, 2015; Valdmann, Holbrook, & Rannikmae, 2017; Zelenak, 2015). Professional development helps the teacher participants to plan classroom lessons that can benefit students' learning as an important factor for implementing meaningful instruction with technology in STEM classes.

Professional development is an effective method for helping teachers to transform their pedagogical practices necessary to improve students learning the content in STEM classes. Kempen and Steyn (2017) posited that professional development assisted teachers to understand the importance of putting students' learning first as a strategy to enhance teaching and learning outcomes. A comprehensive overview of well-designed professional development is necessary to address the deficiencies of student learning in the classroom as revealed by the teacher participants in the study. Professional development serves as an intervention to address the teacher participants' barriers hindering them from planning lessons focused on student learning in STEM classes. Overstreet (2017) posited that professional development is based on the teaching strategies necessary to ensure teachers plan classroom seatwork focused on student learning for adequate instructional practices. Phelps, Kelcey, Jones, and Liu (2016) concurred and asserted that professional development was designed to accommodate all standards governing the teachers' facilitation of student learning for effective technology use and outcomes. The purpose of this professional development project is to train teachers on how to use the TPACK instructional practices in STEM classes. This training will be presented using available computers and manual projectors as instructional technology tools to plan and teach chemistry lessons. This professional development is designed to address the teacher participants' desire to improve their use of technology to plan and teach chemistry lessons on various science curricular content topics. In the next section, I present details for the project implementation, implementation timeline, potential resources, existing supports, potential barriers and solutions, proposal for implementation and timetable, roles and responsibilities, the type of evaluation, justification for using this type of evaluation, the overall goals of the project that will be utilized, and the overall evaluation goals.

Project Description

Implementation

The purpose of this project is to train teachers on how to use the TPACK instructional practices and available computers with manual projectors as instructional technology tools in STEM classes to plan and teach chemistry. The intented goals of the professional development are to:

1. Increase teachers' understanding of using technology to teach chemistry.
2. Increase teachers' frequency of using technology to teach chemistry.
3. Increase teachers' effectiveness of using technology to teach chemistry.

4. Increase teachers' collaboration to plan with peers using technology to teach chemistry.
5. Increase teachers' performance to differentiate instruction using technology to teach chemistry.

The project will cover 3-day campus-based professional development sessions designed for the participants to use available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as technology instructional tools to plan and teach chemistry lessons in STEM classes. The professional development implementation will cover these curriculum topic areas: (a) training on more effectively using the TPACK instructional practices in STEM classes to plan and teach a chemistry lesson on the periodic table of the elements (Group 1 through Group 18) and identify the number of electron charges in each group excluding transition metals (Group 3 through Group 12) as well as identify the number of valence electrons in each element in the groups with available technology tools in their lesson plans, (b) training on more effectively using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on other periodic trends from the periodic table to explain the relative properties of elements based on patterns of atomic structure, (c) training on more effectively using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on the atomic structure from the periodic table of the elements using electron cloud and carbon as the element to identify the number of electrons in each energy level.

Daily PD Topics. The first day of the professional development will offer the teacher participants training on more effectively using the TPACK instructional practices in STEM classes to plan and teach a chemistry lesson on the periodic table of the elements (Group 1 through Group 18) and identify the number of electron charges in each group excluding transition metals (Group 3 through Group 12) as well as identify the number of valence electrons in each element in the groups with available technology tools in their lesson plans. The professional development will offer an introduction to using the available technology as instructional tools to teach STEM classes at the study site. The teacher participants will be asked to design a chemistry lesson on the periodic table of the elements using technology as an instructional tool in STEM classes. The professional development will offer the participants an opportunity to collaborate and identify how they could use technology to teach a chemistry lessons in STEM classes and share their suggestions with each other in an open discussion forum.

The second professional development (PD) session will offer the teacher participants training on more effectively using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on other periodic trends from the periodic table to explain the relative properties of elements based on patterns of atomic structure. The PD will allow the teacher participants opportunity to improve their instructional practices and strategies in STEM lessons using the available instructional technology tools at the study site.

The third professional development (PD) session will offer the teacher participants training on more effectively using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on the atomic structure from the periodic table of the elements using electron cloud and carbon as the element to identify the number of electrons in each energy level. The teacher participants will work in cooperative groups and each group will plan a chemistry lesson based on the atomic structure from the periodic table of the elements. Each group of the teacher participants will share their suggestions in an open discussion forum with other groups of participants.

Implementation Timeline

The PD training will be a 3-day campus-based professional development training sessions. The 3-day training and/or workshop will be conducted at the study site. The 3-day campus-based professional development sessions is designed to train teachers on how to use the TPACK instructional practices and the available instructional technology tools in STEM classes to plan and teach chemistry.

The 3-day campus-based professional development for this project study will require a total of 21 hours of training sessions, from Monday to Wednesday, 9:00 AM to 4:00 PM. The professional development could be placed as on-going and can be conducted anytime during each school year. As the facilitator for this project study, I am available to provide the professional development as on-going process in attempt to resolve the concerns expressed by the teacher participants during the interviews.

Potential Resources

The instructional resources needed to deliver the 3-day campus-based professional development sessions are (a) a computer laboratory to accommodate the teachers and other interested faculty for 3-day training sessions, (b) desktop computers, (c) laptop computers, (d) laptop mobile computer carts, and (e) manual projectors. These instructional technology tools are the available resources at the study site based on the interviews data.

Existing Supports

The district of study uses electronic resources and platforms to communicate with employees, stakeholders, parents, and students. Therefore, teachers at the project study district utilize Moodle Google platform for sharing information with faculty and their students regularly. Professional development campus-based sessions are provided via Moodle Google platform and the associated evaluation forms are completed online in Google docs.

The project study site has a strong instructional support system which includes a STEM Instructional Facilitator that meets with the administrative team regularly. The STEM Instructional Facilitator can provide feedback to the administrative team on the progress of the professional development implementation. The STEM department chair would provide support and coaching strategies to the teacher participants during the professional development.

Potential Barriers and Solutions

Potential barriers for this project include the teacher participants' failure to attend the campus-based workshop. Potential barriers also include conflict in dates for the professional development and/or workshop scheduling. Although the teacher participants are benefiting from the professional development, they may not have the time to participate in the 21 hours campus-based training sessions. The teacher participants' failure to participate in the professional development may result in lack of knowledge to improve their instructional practices in STEM curriculum.

A practical solution to this barrier is to offer the professional development in a 2-hour session afterschool hours during the regular school days. Nevertheless, the overwhelming response from the teacher participants who agreed to participate in this study is proof that they would attend the campus-based professional development at the scheduled time, date, and venue.

The second barrier is conflict in dates scheduling campus-based professional development during the project study district's assigned professional learning days. The school principals are charged with implementing the district mandated professional learning days. It is difficult to schedule this project on those district mandated professional learning days.

A possible solution to this barrier is to offer professional development in a 4-hour session during the district's recommended professional learning days. As the facilitator, I am available to provide the campus-based professional development on a 4-hour sessions during the district recommended professional learning days and/or a 2-hour session after-school hours during any school year.

Proposal for Implementation and Timetable

Professional development for STEM teachers will be scheduled on the district recommended professional learning days. The reason for selecting the district professional learning days is because the STEM teachers will be formally released on those days for the campus-based professional development. Scheduling the professional development on the district professional learning days will eliminate any discrepancies and/or issues arising from the STEM teachers for failure to attend the professional development as scheduled.

Due to a high demand to improve instructional practices in STEM curriculum, the proposed implementation and timetable for this professional development is scheduled for the first semester of 2019-2020 School Year. In addition, this project could be an on-going professional development proposed for the following school year and any other school year.

Timetable for the 3-day professional development campus-based sessions timings will be from 9:00 AM to 4:00 PM as the official district working hours. On each of the 3-day campus-based professional development sessions, the training will last for seven hours, so that by the end of the 3-day professional development sessions, the required 21 hours of professional development will be completed. Table 10 shows the proposed timetable for the 3-day professional development sessions. Refer to Appendix A for the hour-by-hour detail of the 3-day campus-based professional development. See Table 10 for the proposed professional development timetable.

Table 10

Proposed STEM Professional Development Timetable

PD sessions and time	Topics to be covered in PD sessions
STEM Professional Development DAY 1 9:00 AM – 4:00 PM	Participants will receive training on more effectively using the TPACK instructional practices in STEM classes to plan and teach a chemistry lesson on the Periodic Table of the Elements (Group 1 through Group 18) and identify the number of electron charges in each group, excluding transition metals (group 3 through group 12) as well as identify the number of valence electrons in each element in the groups with the available instructional technology tools in their lesson plans.
STEM Professional Development DAY 2 9:00 AM – 4:00 PM	Participants will receive training on more effectively using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on other periodic trends from the Periodic Table of the Elements to explain the relative properties of elements based on patterns of atomic structure.
STEM Professional Development DAY 3 9:00 AM – 4:00 PM	Participants will receive training on more effectively using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on the atomic structure from the Periodic Table of the Elements using electron cloud and carbon as the element to identify the number of electrons in each energy level.

Roles and Responsibilities of Student and Others

Student

Students do not have any role in the 3-day campus-based professional development training. The students would be responsible for participating in the classroom activities that are facilitated by the teachers in STEM classes.

Principal

The school principal is responsible for scheduling dates for the professional development at the project study site. The principal is also responsible for securing the computer laboratory with Internet access for the professional development. In addition, the principal ensures that the laptop computers, desktop computers, laptop mobile computer carts, and manual projectors are available for the professional development.

Facilitator

My established role is to be the facilitator of the professional development. I will generate the learning materials for the training. I am responsible for assisting the teacher participants to learn how to plan and teach chemistry lessons using technology as instructional tools including gaining access to the world-wide web to retrieve the web-based science resources for the training. I will supervise the participants and monitor submission of their completed tasks on the Moodle Google platform. As the facilitator of the professional development, I am the lead teacher in guiding the teacher participants during the 3-day campus-based professional development sessions including the use of the available instructional technology resources in their teaching in STEM classes to improve students' learning outcomes.

Participants

The role of the participants is to engage and carry out the activities designed for the 3-day campus-based professional development (PD). The participants will learn how to plan and teach chemistry lessons using technology as instructional tools including gaining access to the world-wide web and retrieve information from the web-based science resources for the training. The participants will use the available instructional technology tools and the Moodle Google platform to complete their assigned tasks for the professional development training.

Project Evaluation

The evaluation for this project is used to measure the set goals and outcomes of this study including the data sources. At the end of each campus-based PD session, an evaluation form (Appendix A) will be provided to each STEM teacher participant. The participants will evaluate and rate various components of the PD sessions using the survey (Likert scale), questionnaire, and reflective journal.

Participants will complete a formative evaluation and a summative evaluation (see Appendix A for evaluation form). In this project study, the STEM teachers are the stakeholders. The formative evaluation is used to assess the stakeholders' progress in completion of the goals and the outcomes of those goals (Al-Balushi & Al-Abdali, 2015). The formative and summative evaluation are discussed in the sections below.

Justification for Using This Evaluation Approach

This section justify the need for using the formative evaluation and summative evaluation approaches. It is justified to use the formative evaluation in this study because the participants will evaluate and rate various components of the on going PD sessions using the reflection journal and questionnaire. The formative evaluation approach assesses how the professional development goals are met.

It is justified to use the summative evaluation approach in this study because the summative evaluation determines overall effectiveness, progress, and weakness of the PD implementation at the end of the year. At the end of the campus-based PD sessions, summative evaluation will be used to evaluate and rate various components of the overall PD sessions using the survey (Likert scale).

Formative Evaluation

The formative assessment is the first method of evaluation plan. The participants will evaluate and rate various components of the on-going PD sessions using the reflection journal and questionnaire. The formative assessment assesses how the PD implementation goals are met. Al-Balushi and Al-Abdali (2015) posited that the process of project implementation is dependent on the formative evaluation as it assesses on-going progress of the professional development. Valdmann, Holbrook, and Rannikmae (2017) concurred, arguing that formative evaluation provides a systematic way to assess and validate professional development training thereby determining the effectiveness of a design-based, continuous professional development for science teachers (p. 577). The formative assessment is used to provide positive and negative feedback to the stakeholders during the progress of project implementation.

The teacher participants will be asked to write a one-page reflection journal on the success and weakness of the PD sessions. The reflection journals and questionnaire will be used as formative evaluation (see Appendix A) to determine whether the PD goals are met. The questionnaire (see Appendix A) assesses the on-going PD during the district professional learning days to establish how the support structure will help the teacher participants plan and teach chemistry lessons with the available technology instructional tools (*Goal 1 through Goal 3*). The formative evaluation also examines how the support structure will assist the teacher participants to meet the desired PD goals to:

1. Increase teachers' understanding of using technology to teach chemistry.
2. Increase teachers' frequency of using technology to teach chemistry.
3. Increase teachers' effectiveness of using technology to teach chemistry.
4. Increase teachers' collaboration to plan with peers using technology to teach chemistry.
5. Increase teachers' performance to differentiate instruction using technology to teach chemistry.

During the on-going PD sessions, the study district coordinator will analyze the results of the formative assessment and inform the school principal of the feedback and outcomes of the PD. The school principal will disseminate data to all stakeholders to determine whether the formative assessment for the PD implementation is successful.

Summative Evaluation

The summative assessment is the second method of evaluation plan. Summative evaluation determines overall effectiveness,progress, and weakness of the PD project implementation at the end of the year. At the end of the campus-based PD sessions, an evaluation form (Appendix A) will be provided to each STEM teacher participant. The participants will evaluate and rate various components of the overall PD sessions using the survey (Likert scale). The STEM teacher participants will be asked to provide feedback using a survey (Likert Scale) based on the teacher participants' understanding, frequency of technology integration, and effectiveness of the PD. Al-Balushi and Al-

Abdali (2015) contended that summative evaluation helped the “program developers and decision makers” with judgments about the program or training’s overall merit (p. 463). Al-Balushi and Al-Abdali’s (2015) study maintained that summative assessment could measure overall outcomes, which may result in positive or negative feedback from the stakeholders. At the end of the year, the STEM teacher participants will provide feedback on how the PD assisted with creating a support structure that addressed the goals of the PD.

The study district coordinator will analyze the results of the summative assessment and inform the school principal of the overall outcomes. The school principal will disseminate final data to all stakeholders to determine whether the PD for the project was successfully implemented. To understand the efficacy of PD on student learning outcomes in STEM classes, summative assessment will be used to rate the overall effectiveness of the project study. Overall, this PD project aims to strengthen the STEM teachers’ integration of technology as a support structure in various subjects and content areas at the urban school. The PD is intended to provide meaningful and specific training to assist STEM teachers to enhance their use of technology and improve students’ optimal learning outcomes.

Overall Goals of This Project

The overall goals of the PD project is to maximize and/or increase the STEM teachers’ classroom instructional practices and use the available instructional technology tools in STEM classes to teach chemistry. The STEM teacher participants will be asked to provide feedback using a survey (Likert Scale) based on their understanding of the chemistry content and the PD goals (Appendix A).

The overall goals of the PD are to:

1. Increase teachers' understanding of using technology to teach chemistry.
2. Increase teachers' frequency of using technology to teach chemistry.
3. Increase teachers' effectiveness of using technology to teach chemistry.
4. Increase teachers' collaboration to plan with peers using technology to teach chemistry.
5. Increase teachers' performance to differentiate instruction using technology to teach chemistry.

Overall Evaluation Goals of This Project

The overall evaluation goals of the project will be measured using the teacher participants' feedback from the survey (Likert scale) to evaluate the overall PD goals at the end of the year (see Appendix A). The survey (Likert scale) will be used to evaluate the effectiveness of the overall PD goals.

The overall evaluation goals of the project are to:

1. Evaluate the increase of teachers' understanding of using technology to teach chemistry.
2. Evaluate the increase of teachers' frequency of using technology to teach chemistry.
3. Evaluate the increae of teachers' effectiveness of using technology to teach chemistry.

4. Evaluate the increase of teachers' collaboration to plan with peers using technology to teach chemistry.
5. Evaluate the increase of teachers' performance to differentiate instruction using technology to teach chemistry.

Key Stakeholders

The administrators will use the outcomes of the PD to inform the teachers, students, and the community. School administrators are key stakeholders because they release the teacher participants to participate in the PD as well as grant permission to conduct the study at the school site. Crowley (2017) argued that PD assisted teachers in effective classroom instructional practices in district schools (p. 477). Teachers are key stakeholders because they were actively involved in the PD. Cordingley (2015) investigated contribution of research to teachers' professional learning and development. Cordingley's (2015) study found that PD improved evidence-based instructional practices among teachers in the classroom setting. Students are key stakeholders because they are the reason teachers provide feedback on the progress of learning outcomes. Steeg and Lambson (2015) argued that PD helped teachers to facilitate instruction that enhanced students' academic growth (p. 474). Young and MacPhail (2016) investigated "cultivating relationships" with school placement stakeholders. Young and MacPhail's study contended that the "different configurations" of community membership allowed cooperating teachers to contribute towards school placement collaboration. Therefore, the community is a key stakeholder because the school cannot live apart from the community. Effective community involvement and support to the district is pivotal for the students' learning outcomes. Based on the literature, community support helps to shape the school culture and climate to enhance teaching and learning outcomes.

Project Implications Including Social Change

Local Community

The PD has the potential to influence all stakeholders in the local community. The PD would have a major influence on the teachers because they would learn specific instructional practices to address the local problem. By providing the campus-based PD, it is expected that the teacher participants will use the training sessions as a support structure and use the TPACK instructional practices with available instructional technology tools in STEM classes. The success of this project study through a campus-based PD with the teachers teaching STEM classes could lead to expanding this study to other core content teachers at the local district. This PD may help to improve instruction in STEM classes which is important to increase student performance and achievement.

The PD may influence the local district by providing the teachers opportunity to address the learning needs of all students in STEM classes. This project study administered through a campus-based PD may contribute to positive social change by providing teachers a better knowledge and understanding on how to use the TPACK instructional practices with available instructional technology tools in STEM classes.

Larger Context

If the project evaluation indicates that the PD is effective in helping teachers raise students' performance and achievement, then the PD could be implemented simultaneously in other districts across United States to support teachers' instructional practices in the STEM curriculum. Consequently, there is high expectation that positive social change may occur with the STEM instruction among the teacher participants who took part in the PD.

Conclusion

The results of this project study indicated a need for PD to train teachers to use the TPACK instructional practices and strategies with available instructional technology tools in STEM classes. PD was designed to provide meaningful and specific training to assist STEM teachers to enhance their use of technology and better meet students' learning outcomes. In addition, the PD requires teachers to plan and teach chemistry lessons with technology using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as technology instructional tools in STEM classes. In this project study, formative and summative evaluation was important to test the efficacy of the PD to determine the authenticity and/or credibility of the training for the local district. The following section presents a discussion of reflections and conclusions of the study including the project's strengths and limitations, recommendations for alternative approaches, and a personal reflection.

Section 4: Reflections and Conclusions

Reflections and Conclusions

Introduction

This PD project is intended to train teachers on how to use TPACK instructional practices and the available instructional technology tools in STEM classes to plan and teach chemistry. In this section, I discuss the strengths and limitations of my project, including alternative approaches. I also present personal reflections on my growth as a scholar and researcher and make recommendations for future research.

Project Strengths and Limitations

Strengths

This PD was designed as a support resource to help STEM teachers better understand and use instructional technology tools in STEM classes to plan and teach chemistry lessons on the periodic table of the elements. This project was informed by best instructional practices and strategies that have worked successfully for improving the content and pedagogical knowledge of teachers through effective PD (Hummell, 2017, 2018; Porter et al., 2017; Swanson, 2014; Thomas & Kavanaugh, 2018; Yildirim & Sidekli, 2018).

The teacher participants' training on how to plan and teach chemistry lessons during the PD training is a project strength. The participants will receive training on planning their lesson plans using the available instructional technology tools. Participants will also receive training on how to access and integrate the web-based science resources to improve their instructional best practices in their classroom teaching in the STEM curriculum. Learning how to plan and teach chemistry lessons with technology is intended to resolve the problem of technology integration among the teacher participants in STEM classes. I designed this PD project to serve as an intervention for teachers to help them accelerate students' learning in STEM classes.

Limitations

A limiting factor in this project is the possibility of experiencing unforeseen technical difficulties, including obsolete and slow-running computers, in using technology to facilitate instruction in the classroom to enhance students' learning outcomes.

The limitation may be overcome when the district of study provide standby technicians and maintenance crew to tackle the problem whenever it occurs during classroom instructional time to avoid disruption of students' learning.

Recommendations for Alternative Approaches

The problem of technology integration in teachers' instructional practices is a complex issue to explore. As such, there are several alternative approaches that could be considered to address this problem differently based on the work of the study. I could have used a mixed methods study to review the entire study site and/or local district pertaining to technology integration. This alternative approach would have involved surveying teachers and administrators to understand the factors that may affect students' learning outcomes at the study site.

Another approach that could have been used would have involved changing my sample size. For this study, I focused on teachers teaching STEM classes at the study site. A larger sample size would allow me to interview teachers at different urban schools. I used convenience sampling at one urban school for this study. A convenience sampling size limited my findings to one location instead of providing me the opportunity to expand my research findings to other urban schools at the district of study.

I could have interviewed the members of the administrative team at the study site to understand their perspectives on how the problem of technology integration hinders students' learning outcomes. Finially, the curriculum facilitators could have been included to improve technology integration methods in every subject area at the study site.

Scholarship, Project Development, and Leadership and Change

Scholarship

A reflection on this project study helped me to realize the type of knowledge and experience that I gained from my chosen topic. I developed skills as a researcher and collaborated with colleagues on discussion posts as doctoral students in appreciation of the online learning culture. As I reflect on my scholarly writing skills, I remember the feedback that I received from my committee chairman, second committee member, university research reviewer (URR), and other professors who taught me at Walden University. My research skills improved because of the positive feedback that I received from my committee chairman and second committee member, which assisted my research revisions.

Pelger and Larsson (2018) investigated the advancement of scholarship on teaching portfolios to improve teaching and learning outcomes. Pelger and Larsson's study found that the writing of reflective teaching portfolios has the potential to contribute to an emerging academic community of practice characterized by a scholarly approach to teaching and learning. Vithal (2018) concurred, positing that growing a scholarship of teaching and learning institutionally has the potential to contribute to an emerging academic community of practice. Based on the study conducted by Pelger and Larsson, a teaching portfolio is a skill that I acquired that documented the evidence of my teaching goals and philosophy as a teacher. As I conducted this study, I gained skills and knowledge for research-question creation, data collection, data analysis, emerging theme identification, data coding, and interpretation of findings and/or results through online webinars and positive feedback from my professors. My project study helped me gain knowledge and experience to plan a 3-day campus-based PD training as a solution to the local problem.

Project Development

I designed the PD to meet the needs of the teacher participants in maximizing students' learning outcomes in the STEM curriculum. As the PD facilitator, I expect positive results and should be able to provide evidence thereof. A major task in developing the PD is gathering chemistry materials tailored to STEM teachers and using available instructional technology tools at the study site. Knowles, Kelley, and Holland (2018) contended that PD helps teachers to collect learning materials necessary to improve their classroom instructional practices to enhance students' learning outcomes. Al-Balushi and Al-Abdali (2015) posited that using a Moodle-based PD program assisted in training teachers to develop the knowledge needed to teach students to use creativity in the classroom setting. Al-Balushi and Al-Abdali's study focused on assessing teachers' effectiveness in their classroom teaching practices, which helped in project development. Green and Kent (2016) concurred, positing that effective project development may be achieved through PD by developing science and mathematics teachers' knowledge through a science and technology initiative. Consequently, it is important to seek feedback from the participants on how they used technology integration to support their classroom teaching in various subject and content areas at the urban school. In addition, it is important to seek feedback from the teachers on how the PD assisted in providing meaningful and specific training to enhance their use of technology and meet students' optimal learning outcomes.

Leadership and Change

My learning experience at Walden University taught me to be a leader and motivate others to inspire change in the educational field. The planning of the PD enabled me to develop leadership skills in facilitating and inspiring positive change among the teacher participants to address the concerns they expressed during the interviews. Ott (2018) posited that PD helped teachers to improve their classroom strategies through leadership reform in the school setting. Sales, Moliner, and Francisco (2017) concurred, stating that PD helped teachers to collaborate with one another to achieve students' academic growth. Therefore, combining successful leadership and change through an effective PD required the collaborative efforts of the teacher participants in this study.

Analysis of Self as Scholar, Practitioner, and Project Developer

Scholar

My experience as a doctoral student at Walden University has improved my teaching performance and my use of instructional best practices in my own classoom because I have acquired more knowledge and skills through educational research and practice. My research experience enabled me to develop effective PD for teacher participants through the research knowledge I gained from this study. My research experience has given me the opportunity to write with confidence and clarity because I have gained vast knowledge of scholarly writing.

As a scholar, I had the opportunity to use credible sources in my research study. The use of credible sources for my study enhanced my scholarship due to the exposure that I gained to the research literature. As a scholar, I found that exposure to educational research in this study gave me new insight and improved my understanding of the methodology aspect of research design.

Practitioner

As a practitioner, I have found that the knowledge and experience that I have acquired from the research literature have improved my teaching practices with students in the classroom setting. The ideas that I have acquired from my doctoral coursework as well as my research experience have benefited teachers and students who have received my classroom support. For example, I use research-based classroom activities to facilitate instruction in my science classroom. I also help other teachers to use research-based science resources to teach their students in their various classrooms. The experience that I gained in this study exposed me to research knowledge that made me a better science teacher practitioner.

Project Developer

Developing this project study enabled me to understand the components of successful PD by facilitating the PD. By creating PD, I learned about better methods of instructional delivery using technology to teach chemistry lessons in STEM classes. I learned to improve students' academic growth using the available instructional technology tools in STEM classes. As a project developer, I learned instructional strategies with technology that helps me to collaborate with teachers and facilitate classroom activities in STEM classes. Developing this 3-day campus-based PD sessions, I learned to use the PD as a metric for assessing teachers' knowledge of technology integration. Consequently, I gained the skills to become a developer for the 3-day campus-based PD sessions to improve the STEM teachers' technology implementation in their classroom teaching.

Reflection on Importance of the Work

My reflection on the importance of this work led me to recognize that this qualitative bounded case study is important to (a) the participants in the study, (b) the instructional staff and administrators at the urban high school that served as the project study site, and (c) the southeastern U.S. school district's leadership. In this study, I learned that teachers are the most important variable in delivering effective technology instruction in science classrooms. I learned that an effective PD training on technology integration should result in teachers providing students with the opportunity to investigate and find solutions to real-world problems. In this qualitative bounded case study, I learned how to (a) examine the role of technology integration in STEM education, (b) explore new methods and ideas for classroom technology use, (c) eliminate common barriers to technology integration into the STEM curriculum, and (d) integrate available instructional technology tools into the STEM curriculum to enhance students' learning outcomes.

Implications, Applications, and Directions for Future Research

The research for this project study could benefit teachers at the local level and beyond the local level by providing support to educators experiencing difficulty using technology in their classroom for teaching in the STEM curriculum. In addition, this project study could influence PD on incorporating technology in classroom instructional practices as a continuous process in the STEM curriculum. Valdmann et al. (2017) asserted that the effectiveness of a professional development program is intended to promote teachers' self-confidence and skills in the classroom setting (p. 577). I designed this PD project as a support structure for STEM teachers and teachers in other content areas and other school districts in the area. In addition, I designed this PD project to increase technology use in the STEM curriculum.

The data findings from this study led to the design of a 3-day campus-based PD project. Consequently, since STEM teachers were required to use technology in their classroom teaching, it is important that PD be provided to them to address the concerns they expressed during the interviews. In addition to this project study, future research is recommended to increase the efficacy, success, and usefulness of instructional practices in relation to students' optimal learning outcomes in the STEM curriculum.

Implications

A major implication of this project study is that the project may provide STEM teachers with continuous PD support. After the campus-based PD sessions, the STEM teachers need to be continuously supported during the implementation phase of project development to improve their instructional practices. This continuous support is needed for teachers to improve their performance.

Social Change

This qualitative bounded case study examined how teachers implemented technology and described their technology knowledge, content, and pedagogy in their classroom teaching to improve students' learning outcomes in science. Data findings were used to design PD for teachers as a support structure to address the problem of technology integration into STEM classes. The PD has been designed to change teacher participants' instructional practices in STEM classes to promote students' optimal learning outcomes.

The PD is designed to inspire positive social change among the teacher participants by addressing the concerns they expressed during the interviews. According to Ott (2018), positive social change is achieved through PD that helps teachers to accomplish classroom reform in the school setting. Sales, Moliner, and Francisco (2017) concurred, arguing that PD inspires social change when teachers collaborate with one another to improve students' academic growth. Therefore, social change may be achieved through an effective PD that improves the classroom instructional practices of the teacher participants in this study.

Khan and Khan (2017) stated that analysis of different educational systems indicates that efforts made to bring social change reforms through PD and improve the quality of education were fundamentally linked with the quality of teachers (p. 211). As the researcher, I believe that successful implementation of the PD has the potential to begin the process of social change at the study site in this southeastern school district.

Future Research

A major recommendation for future research is to assess the STEM content knowledge and pedagogical knowledge of the teachers to identify their strengths and weaknesses for continuous resolution of the problem of technology integration.To investigate this problem, a qualitative research study could be used. Participant interviews could reveal teachers' knowledge using TPACK and their strengths and weaknesses in integrating technology.

Conclusion

This project study was designed to address the problem of technology integration in STEM classes at the study site in a southeastern U.S. school district. After the implementation of the PD designed for this project study, it is expected that the STEM teacher participants, other subject teachers, and administrators at the urban high school, as well as the leadership at the southeastern school district, will benefit from the study.

After the implementation of the PD training designed for this project study, it is expected that the STEM teacher participants will benefit from the training to improve their technology integration and classroom instructional practices. The study site may benefit from the project because technology integration provides students the opportunity to investigate and find solutions to real-world problems using technology. This project study may benefit the study site because technology integration provides students with an avenue to interact with people of diverse cultures, develop collaborative skills with others, and become active in the global economy.

After the implementation of the PD, the school district may benefit from this project study by resolving any issues with technology integration. The school district may benefit from this project study by receiving data to use in decision making and policy formulation. This project study could benefit the school district by improving students' learning outcomes in STEM classes and other subject areas. In addition, this project study could benefit school administrators at the site by providing PD for other content teachers experiencing difficulty in implementing technology integration into their classroom teaching.

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Appendix A: The Project: Technology Integration Workshop

Effectively Implementing Technology in STEM classes

Introduction

This PD project is designed to help teachers acquire the knowledge and skills required to implement technology integration into their classroom teaching in STEM curriculum. The planning for the professional development is based on the analyzed data and suggested recommendations. This plan can guide implementation of PD for STEM teachers to improve students' optimal learning.

Purpose

The purpose of this PD project is to train teachers on how to use the TPACK instructional practices and available computers with manual projectors as instructional technology tools in STEM classes to plan and teach chemistry. The intention of the PD is to provide meaningful and specific training to assist STEM teachers in their various classrooms to enhance their use of technology and better meet students' learning outcomes. This PD will use available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach chemistry lessons on the periodic table of the elements. The PD training will feature TPACK instructional practices to enable the teachers use technology effectively. The planning and teaching of chemistry lessons using the available technology as instructional tools for the PD was designed based on the concerns expressed by the participants during the interviews.

Target Audience

The target audience for this PD project is science teachers who have direct duties and responsibilities for delivering content material to students in STEM classes at the urban high school selected as the study site. Each of the teachers has over 6 years of experience teaching in secondary education. All the teachers hold Bachelor of Science degrees.

Overall Goals of the PD

The overall goals of the project is to maximize and/or increase the STEM teachers' classroom instructional practices and using available instructional technology tools in STEM classes to improve students' learning outcomes on various science curricular content topics. The STEM teacher participants will be asked to provide feedback using a survey (Likert Scale) based on their understanding of the chemistry content and the PD goals (Appendix A).

The overall goals of the PD are to:

1. Increase teachers' understanding of using technology to teach chemistry.
2. Increase teachers' frequency of using technology to teach chemistry.
3. Increase teachers' effectiveness of using technology to teach chemistry.
4. Increase teachers' collaboration to plan with peers using technology to teach chemistry.
5. Increase teachers' performance to differentiate instruction using technology to teach chemistry.

PD Learning Outcomes

STEM PD is designed to address one of the goals each full day of the 3-day campus-based PD training sessions identified in this project. The learning outcomes of this project are as follows:

Upon successful completion of the Professional Development Day 1, the teacher participants will be able to

- Use the TPACK instructional practices in STEM classes to plan and teach a chemistry lesson on the periodic table of the elements (Group 1 through Group 18) and identify the number of electron charges in each group, excluding transition metals (Group 3 through Group 12) as well as identify the number of valence electrons in each element in the groups with available instructional technology tools in their lesson plans.

Upon successful completion of the Professional Development Day 2, the teacher participants will be able to

- Use the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on other periodic trends from the periodic table to explain the relative properties of elements based on patterns of atomic structure with technology.

Upon successful completion of the Professional Development Day 3, the teacher participants will be able to

- Use the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as instructional technology tools in STEM classes to plan and teach a chemistry lesson on the atomic structure from the periodic table of the elements using electron cloud and carbon as the element to identify the number of electrons in each energy level.

Overall Evaluation Goals of the PD Project

The overall evaluation goals of the project will be measured by the teacher participants' feedback rating from the survey (Likert scale) to evaluate the overall PD goals at the end of the year (see Appendix A). The survey (Likert scale) will be used to evaluate the effectiveness of the overall PD goals. The survey (Likert scale) will be used to measure if the teacher participants attain and/or acquire the skills of the five PD goals. The survey (Likert scale) will evaluate and measure the overall effectiveness of the project (see Appendix A).

The overall evaluation goals of the project are to:

1. Evaluate the increase of teachers' understanding of using technology to teach chemistry.
2. Evaluate the increase of teachers' frequency of using technology to teach chemistry.
3. Evaluate the increase of teachers' effectiveness of using technology to teach chemistry.
4. Evaluate the increase of teachers' collaboration to plan with peers using technology to teach chemistry.

5. Evaluate the increase of teachers’ performance to differentiate instruction using technology to teach chemistry.

Professional Development—Appendix A

Fall 2019

This PD project is intented to be an interactive and collaborative activities for the STEM teacher participants involved in technology implementation to teach chemistry.

This PD is based on current research in the area of technology integration as well as the data findings at an urban high school in a southeastern U.S. school district. The results of this study led to a 3-day campus-based PD in technology implementation to teach chemistry.

This PD will provide effective strategies for technology implementation based on the recommendations of research literature in the area of technology integration.

The PD for STEM teacher participants is divided into 10 content modules which will be used over a 3-day period.

PD Agenda for STEM Teacher Participants

Trainer Notes

TPACK Instructional Practices to be taught in the 3-day PD

1. Benefits of technology instructional tools on students' learning in STEM classes.
2. Benefits of collaborative instructional planning on students' learning in STEM classes.
3. Benefits of differentiated instruction on students' learning in STEM classes.

TPACK Instructional Practices selected for the Chemistry Content Modules to be taught in the 3-day PD

1. Benefits of technology instructional tools on students' learning in STEM classes is selected for the trainer to use and teach the teacher participants modules 2, 3, and 4 as follows:
   a.) **Module 2**– PowerPoint slide 1 – Technology Integration Activity I: The trainer will teach as well as demonstrate to the STEM teacher participants about technology integration for instruction and students' learning. The trainer will teach the participants, what is technology integration?The trainer will teach participants about what research indicated as the benefits of technology integration for teaching and learning. The trainer will show the PowerPoint slide 1and teach the six benefits of technology integration according to the current research literature so that participantswould know the benefits of technology integration to support students' learning. The six benefits of technology integration for instruction that the STEM teacher participants will learn are: (1) technology improves engagement and creates active learners, (2) technology improves knowledge retention, (3) technology encourages individual learning and growth, (4) technology encourages peer collaboration, (5) technology enables students to learn useful life skills, and (6) technology prepares students for real world. The trainer will teach the STEM teacher participants about the advantages and disadvantages of technology integration as well as the barriers of technology integration. The trainer will create handouts about technology integration and distribute to the STEM teacher participants before the presentation of module 2. The trainer will divide the participants into four cooperative small groups of three persons in each group to do the rechnology integration activity..
   b.) **Module 3**–PowerPoint slide 2 – Technology Integrated Chemistry Lesson Activity II: In module 3, the trainer will teach the STEM teacher participants about technology integrated chemistry lesson activity II. The trainer will demonstrate to the STEM teacher participants how to integrate technology in a chemistry lesson using the six benefits of technology integration listed in module 2 with available instructional technology tools. The trainer will create handouts about technology integrated chemistry lesson activity II and distribute to the STEM teacher participants before the presentation of module

3. The trainer will divide the participants into four cooperative small groups of three persons in each group to do the technology integrated chemistry lesson activity II.

c.) **Module 4** – PowerPoint slide 3 – Technology Integrated Web-based Science Resources Chemistry Lesson Activity III. In module 4, the trainer will teach the STEM teacher participants what the web-based science resources are. The web-based science resources that the STEM teacher participants will learn are: (1) http://www.scilinks.org, (2) http://www.khanacademy.com, and (3) http://www.sciencenetlinks.com. The trainer will demonstrate to the STEM teacher participants how to integrate web-based science resources in a chemistry lesson using the six benefits of technology integration listed in module 2 with available technology instructional tools. The trainer will create handouts about the six benefits of technology integration and the three web-based science resources for the lesson activity in this module 4 and distribute to the STEM teacher participants before the presentation begin. The trainer will divide the participants into four cooperative small groups of three persons in each group to do the technology integrated web-based science resources chemistry lesson activity III.

2. Benefits of collaborative instructional planning on students' learning in STEM classes is selected for the trainer to use and teach the teacher participants modules 5, 6, and 7 as follows:

a.) **Module 5** – PowerPoint slide 4 – Collaborative Instructional Planning Activity IV: The trainer will teach the STEM teacher participants about collaborative instructional planning for instruction and student learning. The trainer will teach participants as well as demonstrate to the participants about what research indicated as the benefits of using collaborative instructional planning for teaching and learning. The trainer will teach participants, what is collaborative instructional planning? The trainer will show the PowerPoint slide 4 and explain the three benefits of collaborative instructional planning according to the current research literature so that the participants would know the benefits of collaborative instructional planning to support students' learning. The three types of collaborative instructional planning approaches that participants will learn are: (1) co-teaching approach, (2) consultative and stop-in support approach, and (3) individualized support approach. The trainer will create handouts about collaborative instructional planning and distribute to the STEM teacher participants before the presentation of module 5. The trainer will divide the participants into four cooperative small groups of three persons in each group to do the collaborative instructional planning activity IV.

b.) **Module 6** – PowerPoint slide 5 – Collaborative Instructional Planning Chemistry Lesson Activity V: In module 6, the trainer will teach to the STEM teacher participants about collaborative instructional planning chemistry lesson activity V. The trainer will teach as well as demonstrate to the STEM teacher participants how to collaborate instructional planning in a chemistry lesson on the periodic table of the elements based on patterns of atomic structure using the three different types of collaborative instructional planning approaches listed in module 5 with available technology instructional tools. The trainer will create handouts about collaborative instructional planning and distribute to the STEM teacher participants before the presentation of module 6. The trainer will divide the participants into four cooperative small groups of three persons in each group to do collaborative instructional planning chemistry lesson activity V.

c.) **Module 7** – PowerPoint slide 6 – Collaborative Instructional Planning Using Web-based Science Resources Chemistry Lesson Activity VI: In module 7, the trainer will teach as well as demonstrate to the STEM teacher participants how to use the web-based science resources using the three types of collaborative instructional planning approaches listed in module 5 with the available technology instructional tools to teach a chemistry lesson on other periodic trends from the periodic table of the elements based on patterns of atomic structure. The trainer will create handouts about collaborative instructional planning and distribute to the STEM teacher participants before the presentation of module 7. The trainer will divide the participants into four cooperative small groups to do collaborative instructional planning using the web-based science resources chemistry lesson activity VI.

3. Benefits of differentiated instruction on students' learning in STEM classes is selected for the trainer to use and teach the teacher participants modules 8, 9, and 10 as follows:

a.) **Module 8** – PowerPoint slide 7 – Differentiated Instruction Activity VIII: In module 8, the trainer will teach as well as demonstrate to the STEM teacher participants about how to differentiate instruction for students' learning. The trainer will teach participants about what research literature indicated as the benefits of using differentiated instruction for teaching and learning. The trainer will teach the STEM teacher participants, what is differentiated instruction? The trainer will show PowerPoint slide 7 and teach the four benefits of differentiated instruction according to the current research literature so that participants would know the benefits of differentiated instruction to support students' learning. The four benefits of differentiated instruction approaches that participants will learn are: (1) design lessons based on students' learning styles, (2) group students by shared interest or ability to do assignments, (3) assess students' learning using formative assessment, and (4) continually assess and adjust lesson content to meet students' needs. The trainer will create handouts about differentiated instruction and distribute to the STEM teacher participants before the presentation of module 8. The trainer will divide the participants into four cooperative small groups of three persons in each group to do differentiated instruction lesson activity VIII

b.) **Module 9** – PowerPoint slide 8 – Differentiated Instruction Chemistry Lesson

Activity IX: In module 9, the trainer will teach to the STEM teacher participants about differentiated instruction chemistry lesson activity IX. The trainer will demonstrate to the STEM teacher participants how to differentiate instruction in a chemistry lesson on the atomic structure from the periodic table of the elements utilizing electron cloud and carbon as the element to identify the number of electrons in each energy level using the four benefits of differentiated instruction approaches listed in module 8 with the available technology instructional tools. The trainer will create handouts about differentiated instruction and distribute to the STEM teacher participants before the presentation of module 9. The trainer will divide the STEM teacher participants into four cooperative small groups to do differentiated instruction chemistry lesson activity IX.

c.) **Module 10** – PowerPoint slide 9 – Differentiated Instruction Chemistry Lesson Activity X: In module 10, the trainer will teach the STEM teacher participants how to differentiate instruction to learn different atomic terminology from the periodic table of the elements. The trainer will demonstrate to the STEM teacher participants how to differentiate instruction using the four benefits of differentiated instruction approaches listed in module 8 to learn the terminology of the atomic structure from the periodic table of the elements with available technology instructional tools. The trainer will create handouts about differentiated instruction and distribute to the STEM teacher participants before the presentation of module 10. The trainer will divide the participants into four cooperative small groups of three persons in each group to do differentiated instruction chemistry lesson activity X.

PD Day 1

Time: 9:00AM – 4:00 PM

Module 1: 9:00 AM – 10:00 AM – Welcome and Introduction of the Trainer.
The trainer will take 15 minutes for introduction and read aloud the expectations of the PD training sessions:

- Attend workshop/training on time.
- Maintain professionalism at all times.
- Be respectful to everyone.

During the 15 minutes interval, the trainer will explain that this PD was designed for the STEM teacher participants involved in technology implementation. This PD will provide the STEM teacher participants strategies needed to teach chemistry.

The trainer will take another 15 minutes to divide the STEM teacher participants into cooperative small groups of 3 persons in each group. During the 15 minutes interval, the trainer will place name cards on the tables. The cards with the STEM teacher participants' names will be color coded in blue, red, yellow and so forth. The STEM teacher participants will look for their names and stay in the group where they identify their names (Groups A, B, C, & D). Now, the trainer will distribute the PowerPoint handouts to the STEM teacher participants.

After the STEM teacher participants have located their names in their various cooperative small groups, they will be allowed 30 minutes to interact with each other about the PD. During the 30 minutes interval, the trainer will review the key points in the handouts with the STEM teacher participants. This PowerPoint handouts lists the overview of the lesson that will be addressed during the 3-day campus-based PD using the available laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as technology instructional tools to teach chemistry.

BREAK 10.00 AM – 10:15 AM

Module 2:10:15 AM – 1:00 PM
After the break, the trainer will continue PowerPoint slide 1: Technology Integration Activity I. At the beginning of module 2, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before presentation begin. The trainer will teach the STEM teacher participants about technology integration for instruction and students' learning using laptop and desktop computers as technology instructional tools. The trainer will present the PowerPoint slide 1 that list the six benefits of technology integration according to research so that participants would know the benefits of technology integration to support students' learning. The six benefits of technology integration that the trainer will teach the STEM teacher participants using laptop and desktop computers for instruction are as follows:

(1) technology improves engagement and creates active learners.

(2) technology improves knowledge retention.
(3) technology encourages individual learning and growth.
(4) technology encourages peer collaboration.
(5) technology enables students to learn useful life skills.
(6) technology prepares students for real world.

The trainer will teach the STEM teacher participants, what is technology integration? The trainer will teach the STEM teacher participants about the six benefits of technology integration using available technology instructional tools for instruction as follows:

(1) How can technology improve engagement and create active learners?
(2) How can technology improve knowledge retention?
(3) How can technology encourage individual learning and growth?
(4) How can technology encourage peer collaboration?
(5) How can technology enable students to learn useful life skills?
(6) How can technology prepare students for real world?

The trainer will teach the STEM teacher participants the following:

1. What are the advantages of technology integration for instruction and students' learning?
2. What are the disadvantages of technology integration for instruction and students' learning?
3. What are the barriers of technology integration for classroom instruction?

The trainer will demonstrate to the STEM teacher participants how to teach a chemistry lesson on the atomic structure from the periodic table of the elements with the six benefits of technology integration using a laptop computer for instruction as technology instructional tools. During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the benefits of technology integration. The trainer's handouts explain the details of module 2 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 2.

According to current research literature, educators have come to understand that integration of technology in classroom instruction for students made 21st-century learning possible (Sadaf, Newby, & Ertmer, 2016). Waters, Kenna, and Bruce (2016) posited that an essential feature for effective classroom instruction in district schools is integrating technology effectively in classroom instruction. According to Waters et al.'s study, integration of technology involves using technology resources for effective classroom instruction, including computers, mobile devices such as smartphones and tablets, digital cameras, social media platforms and networks, software applications, and the Internet. Waters et al. argued that these technological resources and tools are needed for effective classroom instruction in daily routine practices in secondary schools. Hollingsworth and Lim (2015) argued that effective classroom instruction is achieved when teachers' use of technology is routine, accessible, transparent, and readily available to solve classroom seatwork tasks, supporting curriculum goals and objectives and assisting students in attaining mastery skills. Shlossberg and Cunningham (2016) contended that effective classroom instruction is achieved when students can use technology tools to obtain information on time, analyze and synthesize information, and present the information to other students. Almeida, Jameson, Riesen, and McDonnell (2016) posited that effective classroom instruction is achieved when technology combined with instruction increases learning and provides students access to current primary source materials in schools.

After the trainer finished teaching PowerPoint slide 1 and demonstration on the benefits of technology integration, the trainer will ask each of the four groups of STEM teacher participants to discuss what they learned about the six benefits of technology integration for instruction and students' learning in front of the other groups in the open forum.

LUNCH 1:00 PM – 2:00 PM

Module 3: 2:00 PM – 3:00 PM
After lunch, the trainer will continue module 3 PowerPoint slide 2: Technology Integrated Chemistry Lesson Activity II. At the beginning of module 3, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before the presentation begins. The trainer will teach the participants about technology integrated chemistry lesson activity II using the laptop and desktop computers for instruction as technology instructional tools. The trainer will demonstrate to the STEM teacher participants how to use the laptop computer as technology instructional tools and teach the six benefits of technology integration approaches in a chemistry lesson as follows:

(1) How can technology improve engagement and create active learners?
(2) How can technology improve knowledge retention?
(3) How can technology encourage individual learning and growth?
(4) How can technology encourage peer collaboration?
(5) How can technology enable students to learn useful life skills?
(6) How can technology prepare students for real world?

During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the six benefits of technology integration in a chemistry lesson. The trainer's handouts explain the details of module 3 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 3. After the demonstration of the chemistry lesson activity, the trainer will divide the participants into four cooperative small groups of three persons in each group. The trainer will ask each of the four groups of STEM teacher participants to do a 10 minutes presentation about what they learned from the trainer's demonstration to other groups in the open forum.

BREAK 3:00 PM – 3:15 PM

Module 4: 3:15 PM – 4:00 PM
After the break, the trainer will continue module 4 PowerPoint slide 3: Technology Integrated Web-based Science Resources Chemistry Lesson Activity III. At the beginning of module 4, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before presentation begin. In module 4, the trainer will

teach the STEM teacher participants, what are the web-based science resources?
The web-based science resources that the trainer will teach the STEM teacher participants are as follows:

(1) http://www.scilinks.org,
(2) http://www.khanacademy.com
(3) http://www.sciencenetlinks.com.

The trainer will teach the STEM teacher participants how to use the http://www.khanacademy.com to retrieve the periodic table of the elements and carbon electron cloud. The trainer will teach the STEM teacher participants how to use the http://www.scilinks.org to retrieve potassium, hydrogen, magnesium, calcium, and boron as parts of the atomic structure from the periodic table of the elements. The trainer will teach the STEM teacher participants how to use http://www.sciencenetlinks.com to retrieve chlorine, oxygen, carbon, helium, and nitrogen as parts of the atomic structure from the periodic table of the elements.
The trainer will demonstrate to the STEM teacher participants how to use the laptop and desktop computers to teach the six benefits of technology integration approaches for instruction and students' kearning as follows:

(1) How can technology improve engagement and create active learners?
(2) How can technology improve knowledge retention?
(3) How can technology encourage individual learning and growth?
(4) How can technology encourage peer collaboration?
(5) How can technology enable students to learn useful life skills?
(6) Howcan technology prepare students for real world?

During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the technology integrated web-based science resources chemistry lesson. The trainer's handouts explain the details of module 4 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 4. After the trainer's demonstration of the chemistry lesson, the trainer will divide the participants into four cooperative small groups of three persons in each group. The trainer will instruct each of the four groups of STEM teacher participants to discuss what they learned from the trainer's demonstration in front of the other groups in the open forum.

PD Day 2

Time: 9:00 AM – 4:00 PM

Module 5: 9:00 AM – 10:00 AM
The trainer will continue PowerPoint slide 4: Collaborative Instructional Planning Chemistry Lesson Activity IV. At the beginning of module 5, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before presentation begin. The trainer will teach the STEM teacher participants about collaborative instructional planning for instruction and students' learning using the laptop and desktop computers as technology instructional tools. The trainer will present

the PowerPoint slide 4 that list the three benefits of collaborative instructional planning according to research so that participants would know the benefits of collaborative instructional planning to support students' learning. The three benefits of collaborative instruction planning that the trainer will teach the STEM teacher participants with technology instructional tools are as follows:

1. Co-teaching approach
2. Consultative and stop-in support approach
3. Indivilualized support approach

The trainer will teach the participants, what is collaborative instructional planning? The trainer will teach the STEM teacher participants how to do collaborative instructional planning with the three benefits of collaborative instructional planning approaches using laptop and desktop computers for instruction as technology instructional tools as follows:

1. How can technology be used in co-teaching approach?
2. How can technology be used in consultative and stop-in support approach?
3. How can technology be used in individualized support approach?

The trainer will demonstrate to the STEM teacher participants how to do collaborative instructional planning in a chemistry lesson on the atomic structure from the periodic table of the elements with the three benefits of collaborative instructional planning approaches. During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the three benefits of collaborative instructional planning. The trainer's handouts explain the details of module 5 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 5.

According to the current research literature, collaborative instructional planning has a positive influence on the success of students' learning (Nichols & Sheffield, 2014). Here is one example, students with disabilities in collaborative classes tend to score higher in state standardized tests than students with disabilities in self-contained classes (Gladman, 2014). In addition, research literature indicated that high school students' test grades in general and special education collaborative classes improved at higher rates (Jao & McDougal, 2016). Chandler-Olcott and Nieroda (2016) posited that collaborative instructional planning helps teachers to grow as educators to improve instruction as well as help to provide needed attention to students in the classroom. In support of this notion, Park (2014) asserted that research shows teachers experience growth and increased knowledge when they participate in collaborative instructional planning to enhance students' learning.

After the trainer finished teaching PowerPoint slide 4 and demonstration on the three benefits of collaborative instructional planning, the trainer will ask each of the four groups of STEM teacher participants to discuss what they learned about the three benefits of collaborative instructional planning for instruction and students' learning in front of the other groups in the open forum.

BREAK 10:00 AM – 10:15 AM

Module 6: 10:15 AM – 1:00 PM

After the break, the trainer will continue module 6 PowerPoint slide 5: Collaborative Instructional Planning Chemistry Lesson Activity V. At the beginning of module 6, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before presentation begin. The trainer will teach the STEM teacher participants about the three benefits of collaborative instructional planning chemistry lesson. The trainer will demonstrate to the STEM teacher participants how to do collaborative instructional planning to teach a chemistry lesson on the atomic structure from the periodic table of the elements with the three benefits of collaborative instructional planning approaches as follows:

1. How can technology be used in co-teaching approach?
2. How can technology be used in consultative and stop-in support approach?
3. How can technology be used in individualized support approach?

During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the three benefits of collaborative instructional planning. The trainer's handouts explain the details of module 6 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 6. The trainer will ask each of the four groups of STEM teacher participants to do a10 minutes presentation to discuss what they learned from the demonstration to other groups of participants in the open forum.

LUNCH 1:00 PM – 2:00 PM

Module 7: 2:00 PM – 4:00 PM

After lunch break, the trainer will continue module 7 PowerPoint slide 6: Collaborative Instructional Planning Web-based Science Resources Chemistry Lesson Activity VI. At the beginning of module 7, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before presentation begin. The trainer will teach the STEM teacher participants, what are the web-based science resources?

The web-based science resources that the trainer will teach the STEM teacher participants are as follows:

(1) http://www.scilinks.org
(2) http://www.khanacademy.com
(3) http://www.sciencenetlinks.com

The trainer will teach the STEM teacher participants how to use the http://www.khanacademy.com to retrieve the periodic table of the elements and carbon electron cloud. The trainer will teach the STEM teacher participants how to use the http://www.scilinks.org to retrieve potassium, hydrogen, magnesium, calcium, and boron as parts of the atomic structure from the periodic table of the elements. The trainer will teach the STEM teacher participants how to use http://www.sciencenetlinks.com to retrieve chlorine, oxygen, carbon, helium, and nitrogen as parts of the atomic structure from the periodic table of the elements.

The trainer will demonstrate to the STEM teacher participants how to do collaborative instructional planning in a chemistry lesson on the parts of atomic structure from the periodic table of the elements with the three benefits of collaborative instructional planning approaches as follows:

1. How can technology be used in co-teaching approach?
2. How can technology be used in consultative and stop-in support approach?
3. How can technology be used in individualized support approach?

During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the three benefits of collaborative instructional planning. The trainer's handouts explain the details of module 7 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 7. The trainer will instruct each of the four groups of STEM teacher participants to discuss what they learned in front of the other groups in the open forum.

PD Day 3

Time: 9:00 AM – 4:00 PM

Module 8: 9:00 AM – 11:00 AM
The trainer will continue PowerPoint slide 7: Differentiated Instruction Activity VII. At the beginning of module 8, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before presentation begin. The trainer will teach the STEM teacher participants about differentiated instruction on students' learning using the laptop and desktop computers as technology instructional tools. The trainer will present the PowerPoint slide 7 that list the four benefits of differentiated instruction according to research so that participants would know the benefits of differentiated instruction to support students' learning. The trainer will teach the STEM teacher participants, what is differentiated instruction?
The trainer will teach the STEM teacher participants the four benefits of differentiated instruction using laptop and desktop computers for instruction as follows:

1. Design lesson based on students' learning styles
2. Group students based on shared interest or ability to do assignments.
3. Assess students' learning through formative assessment.
4. Continually assess and adjust lesson content to meet students' needs.

The trainer will teach the STEM teacher participants how to differentiate instruction with the four benefits of differented instruction approaches using laptop and desktop computers for instruction as technology instructional tools.
The trainer will demonstrate to the STEM teacher participants how to differentiate instruction to teach a chemistry lesson on the atomic structure from the periodic table of the elements with the four benefits of differentiated instruction approaches using a laptop computer for instruction as follows:

1. How can technology help to design lesson based on students' learning styles?
2. How can technology help to group students based on shared interest or ability to do assignments?
3. How can technology help to assess students' learning through formative assessment?

4. How can technology help to continually assess and adjust lesson content to meet students' needs?

During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the four benefits of differentiated instruction. The trainer's handouts explain the details of module 8 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 8.

According to the current research literature, differentiated instruction is teaching the same material to all the students in the classroom setting using different instructional strategies (Tomlinson, 2014). In support of this notion, Chin-Wen (2015) posited that differentiated instruction require teachers to deliver instruction at varying levels of difficulty based on the ability of each student in the classroom. One of the identified benefits of differentiated instruction according to the literature is that it helps to meet students where they are in the learning process (pre-assessing) to determine the steps to get the students where they need to be (Taylor, 2015).

After the trainer finished teaching PowerPoint slide 7 and demonstration on the four benefits of differentiated instruction, the trainer will ask each of the four groups of STEM teacher participants to discuss what they learned about the four benefits of differentiated instruction to support students' learning in front of the other groups in the open forum.

BREAK 11:00 AM – 11:15 AM

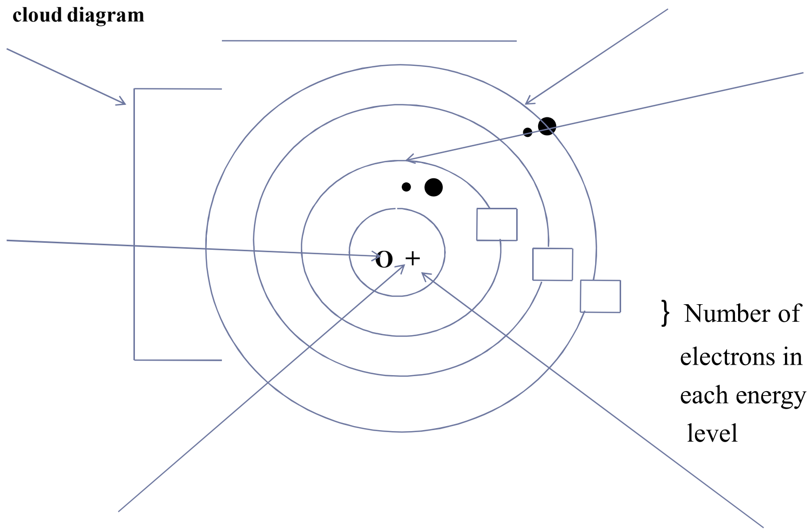
Module 9: 11:15 AM – 1:00 PM

The trainer will continue module 9 PowerPoint slide 8: Differentiated Instruction Lesson Activity VIII. At the beginning of module 9, the trainer will distribute the handouts prepared for this module to the STEM teacher participants laptop computers, desktop computers, manual projectors, and laptop mobile computer carts to teach a chemistry lesson on the atomic structure from the Periodic Table of the Elementsperiodic table of the elements utilizing electron cloud and carbon as the element to identify the number of electrons in each energy level with the four benefits of differentiated instruction approaches using a laptop computer for instruction as follows:

1. How can technology help to design lesson based on students' learning styles?
2. How can technology help to group students based on shared interest or ability to do assignments?
3. How can technology help to assess students' learning through formative assessment?
4. How can technology help to continually assess and adjust lesson content to meet students' needs?

See PowerPoint diagram of carbon electron cloud and carbon atomic structure below. During the trainer's demonstration, the STEM teacher participants will look at their handouts to help them understand the demonstration on the four benefits of differentiated instruction. The trainer's handouts explain the details of module 9 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 9. The trainer will ask each of the four groups of STEM teacher participants to do a 10 minutes presentation about what they learned from the demonstration to other groups of participants in the open forum.

Module 9 - Chemistry Lesson Activity VIII A: Carbon electron cloud diagram



Module 9 - Chemistry Lesson Activity VIII B – Carbon structure diagram

LUNCH 1:00 PM – 2:00 PM

Module 10: 2:00 PM – 4:00 PM
After lunch, the trainer will continue module 10 PowerPoint slide 9: Differentiated Instruction Lesson Activity IX. At the beginning of module 10, the trainer will distribute the handouts prepared for this module to the STEM teacher participants before presentation begin. The trainer will teach the STEM teacher participants about differentiated instruction on students' learning using the laptop and desktop computers for instruction. The trainer will present the PowerPoint slide 9 that list the four benefits of differentiated instruction.
The trainer will demonstrate to the STEM teacher participants how to differentiate instruction in a chemistry lesson on the terminology of atomic structure from the periodic table of the elements with the four benefits of differentiated instruction approaches as follows:

1. How can technology help to design lesson based on students' learning styles?
2. How can technology help to group students based on shared interest or ability to do assignments?
3. How can technology help to assess students' learning through formative assessment?
4. How can technology help to continually assess and adjust lesson content to meet students' needs?

See PowerPoint chart on the terminology of atomic structure below.

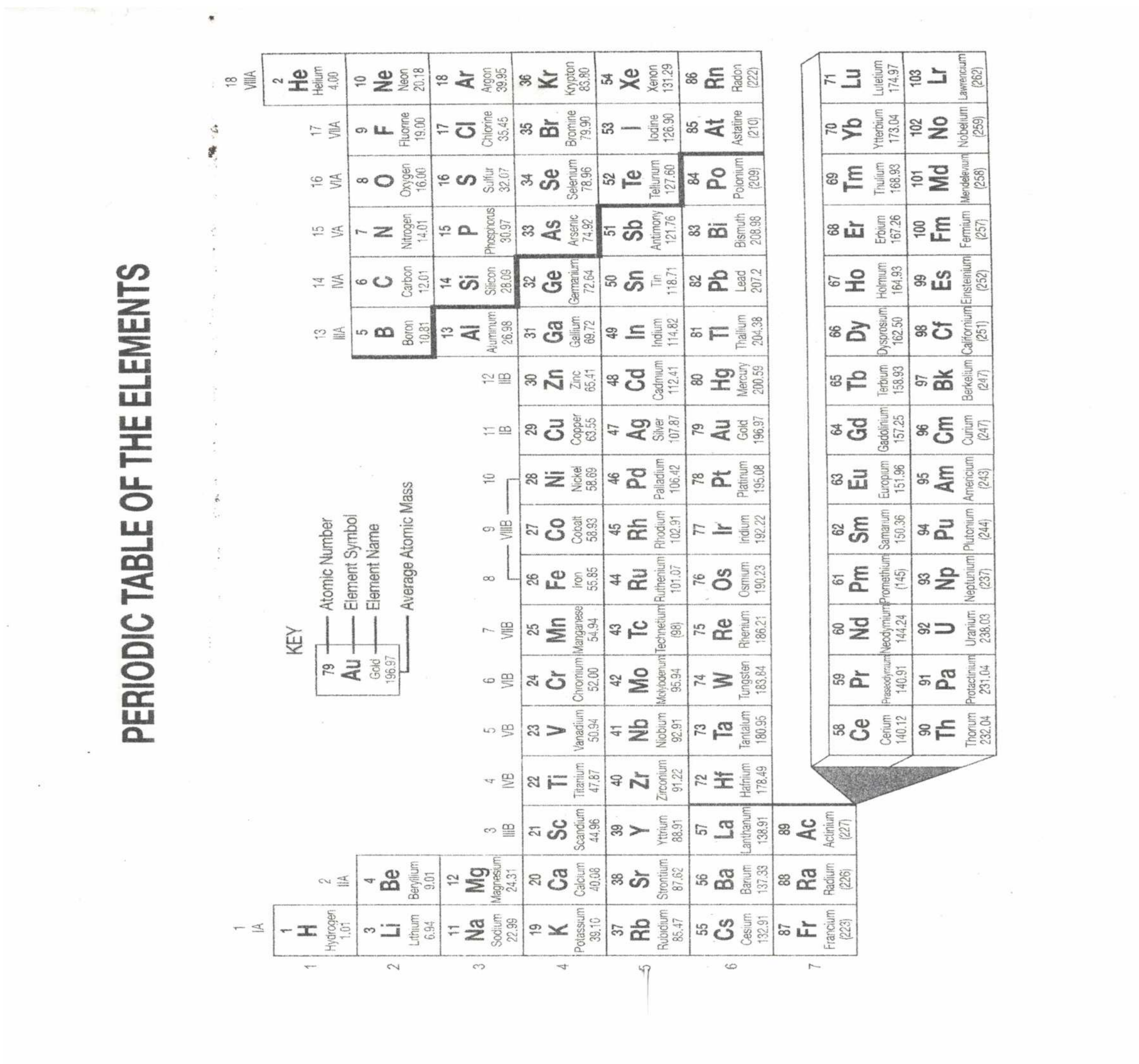
During the trainer's demonstration, the STEM teacher participants will review their handouts to help them understand the demonstration on the four benefits of differentiated instruction about the terminology of atomic structure. The trainer's handouts explain the details of module 10 so that the STEM teacher participants can use the handouts and add notes as needed to clearly understand module 10. The trainer will instruct each of the four groups of STEM teacher participants to do a 10 minutes presentation about what they learned from the demonstration of atomic structure terminology.

At the end of module 10, the STEM teacher participants will complete the survey (Likert scale) [see Appendix A] pertaining to the 3-day campus-based PD that mark the end of the workshop/training.

Module 10 – Chemistry Lesson Activity IX - Atomic Structure Terminology

Atom	Electron Cloud
Nucleus	Electron
Proton	Energy Levels
Neutron	Valence Electron
Atomic Number	Atomic Mass

Learning Elements of the 3-Day Campus-based Professional Development



PowerPoint for STEM Teachers: Day 1 – Day 3
Modules 2-10

PD Day 1: Module 2

How can technology integration benefits help students learn in STEM classes?

The six benefits of technology integration on students' learning in STEM classes according to the research literature are as follows:

- **technology improves engagement and creates active learners.**
- **technology improves knowledge retention.**
- **technology encourages individual learning and growth.**
- **technology encourages peer collaboration.**
- **technology enables students to learn useful life skills.**
- **technology prepares students for real world.**

PD Day 1: Module 3

How can the six benefits of technology integration approaches help to teach chemistry in STEM classes?

- **How can technology improve engagement and create active learners in STEM classes?**
- **How can technology improve students' knowledge retention in STEM classes?**
- **How can technology encourage individual students' learning and growth in STEM classes?**
- **How can technology encourage peer collaboration in STEM classes?**
- **How can technology enable students to learn useful life skills in STEM classes?**
- **How can technology prepare students for real world?**

PD Day 1: Module 4

Use of web-based science resources for technology integration in STEM classes.

How can technology integrated web-based science resources help to teach chemistry and various content topics to improve optimal students' learning outcomes and achievement levels in STEM classes?

PD Day 2: Module 5

How can collaborative instructional planning benefits help students learn in STEM classes?

The three benefits of collaborative instructional planning according to the research literature are as follows:

- **Co-teaching approach**
- **Consultative and stop-in support approach**
- **Individualized support approach**

PD Day 2: Module 6

How can the three collaborative instructional planning benefits with technology instructional resources help students learn in STEM classes?

Think:

- **How can technology instructional resources be used in co-teaching approach?**
- **How can technology be used in consultative and stop-in support approach?**
- **How can technology be used in individualized support approach?**

PD Day 2: Module 7

Use of technology integrated web-based science resources retrieved from the world-wide web to help students learn in STEM classes.

Think:

How can technology integrated web-based science resources retrieved from the world-wide web improve students' performance and achievement in STEM classes?

PD Day 3: Module 8

How can differentiated instruction benefits help students learn in STEM classes?

The four benefits of differentiated instruction according to the research literature are as follows:

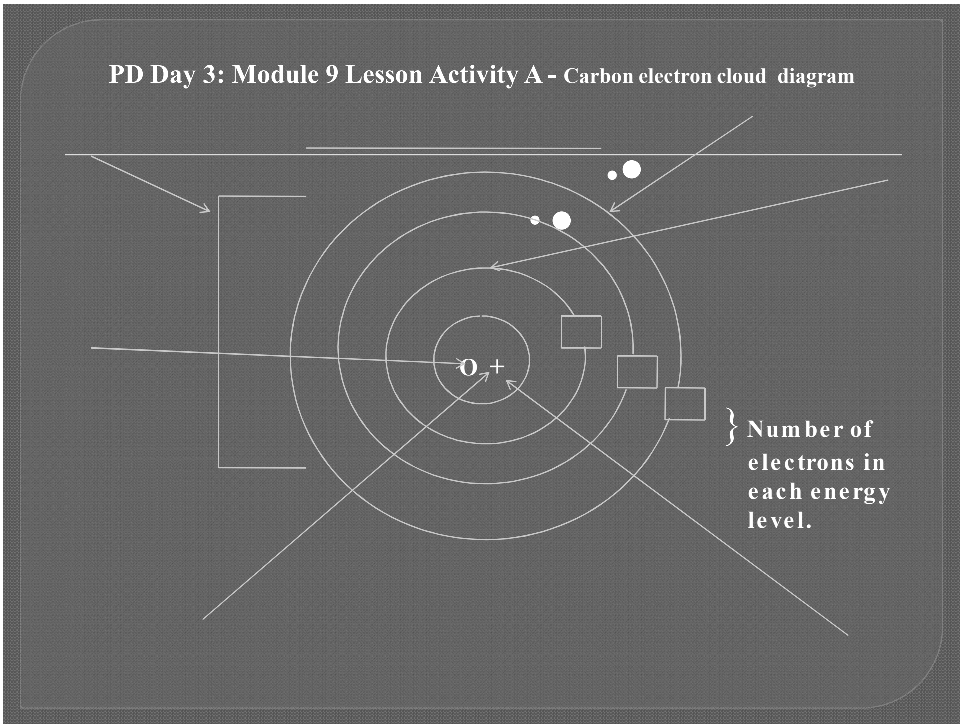
- **Design lesson based on students' learning styles**
- **Group students based on shared interest or ability to do assignments.**
- **Assess students' learning through formative assessment.**
- **Continually assess and adjust lesson content to meet students' needs.**

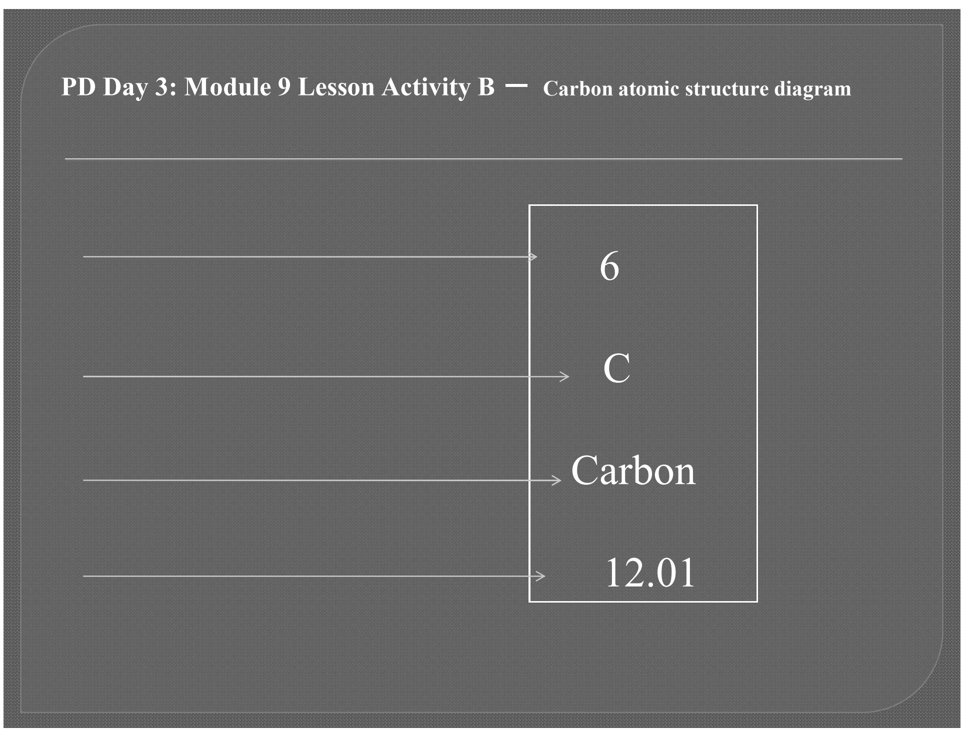
PD Day 3: Module 9

How can the four benefits of differentiated instruction approaches with technology instructional resources help to teach chemistry in STEM classes?

Think:

- **How can technology help to design lesson based on students' learning styles?**
- **How can technology help to group students based on shared interest or ability to do assignments?**
- **How can technology help to assess students' learning through formative assessment?**
- **How can technology help to continually assess and adjust lesson content to meet students' needs?**


PD Day 3: Module 9 Lesson Activity A - Carbon electron cloud diagram
o +
Number of electrons in each energy level.


PD Day 3: Module 9 Lesson Activity B – Carbon atomic structure diagram
6
C
Carbon
12.01

PD Day 3: Module 10

Use of differentiated instruction benefits with technology instructional resources from the world-wide web to help students learn chemistry terminology in STEM classes.

Think:

How can differentiated instruction with technology instructional resources help students understand the chemistry terminology of atomic structure in STEM classes?

PD Day 3: Module 10 Lesson Activity – Chemistry Terminology chart

Atom	Electron Cloud
Nucleus	Electron
Proton	Energy Levels
Neutron	Valence Electron
Atomic Number	Atomic Mass

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The Project:Technology Integration Workshop

Evaluation Forms—Appendix A

Formative Evaluation

Reflection Journal

Write a one-page reflection journal on the success and weakness of the professional development sessions that were conducted since the beginning of the year. In your own personal experience, reflect on the overall professional development and provide any details you believe are important for the continued success of STEM teachers' instructional practices in urban schools.

Questionnaire

1. If you participated in professional development sessions, how have those sessions influenced students' engagement and performance in your STEM classes?
2. How have professional development sessions influenced students' learning outcomes in your STEM classes?

Summative Evaluation

Survey (Likert scale)

1. I am satisfied with my PD learning opportunities because the PD increased my understanding of using technology to teach chemistry.

   ( ) Strongly Agree

   ( ) Agree

   ( ) Neutral/Neither disagree nor agree

   ( ) Disagree

   ( ) Strongly Disagree

2. I am pleased with the increased frequency of using instructional technology as an advancement opportunities available to me through the PD.

   ( ) Strongly Agree

   ( ) Agree

   ( ) Neutral/Neither disagree nor agree

   ( ) Disagree

   ( )Stringly Disagree

3. I am pleased with the effectiveness of the PD sessions using instructional technology as advancement opportunities available to me through the PD.

   ( ) Strongly Agree

   ( ) Agree

   ( ) Neutral/Neither disagree nor agree

   ( ) Disagree

( ) Strongly Disagree

4. I am pleased with the increased collaboration to plan with peers using instructional technology to teach chemistry.

   ( ) Strongly Agree

   ( ) Agree

   ( ) Neutral/Neither disagree nor agree

   ( ) Disagree

   ( ) Strongly Disagree

5 Overall, the PD sessions was effective by providing me the skills to increase performance in differentiated instruction using instructional technology to teach chemistry.

   ( ) Strongly Agree

   ( ) Agree

   ( ) Neutral/Neither disagree nor agree

   ( ) Disagree

   ( ) Strongly Disagree

Appendix B: Document Review Checklist

Researcher created document review checklist from the teachers' weekly lesson plans used as a guide and provide consistency across participants' document analysis. The checklist will validate how participants are using technology related to the TPACK framework and other educational tools to improve students' learning outcomes.

DOCUMENT REVIEW CHECKLIST FOR TEACHERS' LESSON PLAN

Teachers' Technology Use and Knowledge		**Notes**
1. Specific parts of teachers' technology knowledge related to TPACK framework to improve students' learning outcomes? • Teacher Technology Knowledge_______ • Teacher Pedagogy Knowledge_________ • Teacher Content Knowledge__________ • Student-centered learning____________ • Student Engagement________________ • Student Performance________________ • Student Task Accomplishment________ • Student Achievement________________ 2. Specific parts of teachers' technology use to improve students' learning outcomes? • Blended Learning with students_______ • Computer Simulations with students____ • Computer Animation and Gaming_____ • Interactive Smart boards usage_______ • Digital and Manual Projectors usage___ • Computer Laboratory usage__________ • Computer Virtual Laboratory usage___ • Critical Thinking with Technology_____ • Problem Solving with Technology_____ • Social Networking Sites Usage________ • Content Learning with Technology___ • Vocabulary Learning with Technology__ • Web-based Science Sites usage____ • Laptop/Desktop Computer usage____		

Appendix C: Interview Protocol

INTERVIEW PROTOCOL

Time of Interview:

Date:

Place:

Interviewer:

Interviewee:

Position of Interviewee:

The purpose of this qualitative case study is to examine how 12-15 teachers at the project study site integrated technology in their classroom teaching to improve students' learning in science. Therefore, I would like to interview you. The interview will take approximately 30 minutes to 45 minutes to complete. The information obtained from this interview session will be kept confidential. Your identity will not be disclosed to anyone. I will be conducting the same interview with other science teachers in the school building.

Interview questions:

1. What technology do you have in your classroom to teach STEM classes?
2. What steps do you take in planning to integrate technology in STEM classes?
3. How does your understanding of STEM content help you to integrate technology?
4. What science concepts and teaching strategies do you consider and include when planning lessons that integrate technology?

5. How do you plan for student learning when technology integration is part of teaching the content? How do you use technology to determine whether the students have learned the content?
6. What teaching methods do you use when integrating technology in your STEM classes? What is the purpose of integrating technology in your classes?
7. How do you select technology to teach STEM content? How do you know if the chosen technology will assist or hinder teaching the content? How do you know if the chosen technology will assist or hinder students learning the content? What do you do if the chosen technology hinders instruction or student learning? How do you assess student content knowledge?
8. How do you decide which technology to use to teach problem solving in the STEM classes you teach? Tell me about a lesson you taught using technology to teach problem solving.
9. How do you decide which technology to use to teach critical thinking in your STEM classes? Tell me about a lesson you taught using technology to teach critical thinking.
10. How do you decide which technology to use to teach decision making in your STEM classes? Describe a lesson you taught using technology to teach students how to make decisions.
11. Give me an example when you taught a science concept that required you to use multiple technologies to represent the concept you were teaching. How did you adapt those technologies to activate student prior knowledge? How did you tailor

those technologies to teach critical thinking? How did you tailor those technologies to teach problem solving?

12. How has your teaching changed because you integrated technology in your instruction? How has student learning changed because you integrated technology? What teaching constraints did you experience when you used technology? What teaching strategies did you use to teach specific content when you integrated technology?
13. What barriers may hinder technology integration in science instruction? How do you address barriers to integrate technology?
14. What recommendations would you suggest for teachers considering integrating technology in science instruction?

14a. Is there anything else you would like to add?

Thank you for attending and participating in this interview session.

Sample of probing/follow-up questions:

Tell me more about…"

"Explain what happened as a result of your decision."

"What did you learn about…?"

Please give me an example of…?