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STEM In Practice: A Qualitative Exploration on Effectively Implementing Technology in High Schools

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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 explore how teachers integrated technology into their teaching to improve science students' learning outcomes. 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 semi-structured interviews. Typological analysis was used to code and summarize data into emerging themes. Teachers used instructional tools and sources to help students learn. District administrators may provide STEM teachers with technology tools and training to improve science instruction and optimal learning outcomes for students.

Keywords: Technology, education, STEM, science education, instruction, curriculum, high school science, high school science teachers

For several years, school districts across the United States (U.S.) 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). Across the U.S., 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). 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 (Reiss & Millar, 2014). 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.

There are challenges to technology integration in science education that can hinder the effectiveness of this effort (Gibson, 2013). The general problem associated with technology integration impedes teachers' delivery of effective instruction in science classrooms. At the research site, a gap in practice exists in that it was 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 district's 2013-2015 technology integration plan, the technological investment to increase teachers' classroom instructional delivery in the science department at the research site was unsuccessful. The leadership team at the research 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 problem is that it was unknown how teachers implemented technology and described their technology, pedagogy, and STEM content knowledge to improve students' learning outcomes in science. Demirel 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;). Other researchers (Al Musawi, Ambusaidi, Al-Balushi, & Al-Balushi, 2015) have called for further investigation in the area of technology integration to enhance students' learning outcomes in science.

Research Questions

The purpose of this bounded qualitative case study was to explore how teachers integrated technology in their classroom teaching to improve students' learning outcomes in science. The following research questions 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

Conceptual Framework

In this research study, the technology, pedagogy, and content knowledge (TPACK) was used 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 (2006) 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 in analyzing qualitative data to answer the research questions posed in this research study.

The TPACK framework contained the typologies that were used to analyze the data. In a research study, Tondeur, Braak, Ertmer, and Ottenbreit-Leftwich (2017) 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.

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 (Van Horne, Russell, & Schuh, 2016).

Benefits of Professional Development on Instructional Technology Use

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). 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-Abdali (2015) contended that professional development is more effective when using a Moodle-based professional development program to train science teachers. Al-Balushi and Al-Abdali 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 (Kriek& Coetzee, 2016). 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.

Research Design and Methodology

Participants

A total of 12 teachers from a pool of 18 teachers in the science department at the research 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 purposeful 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 in depth. 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.

Data Collection

The sources of data collection for this qualitative 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.

Documents

The first set of data collected in this research study consisted of teachers' weekly lesson plans. A time was scheduled to meet with each participating teacher, and it was requested that each teacher submit two weekly lesson plans at least two weeks before the scheduled interview. It was explained to each participant that items in the weekly lesson plans were to include documentation on how teachers integrated technologies into their classroom teaching and learning in the STEM curriculum.

A document review was created 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. The document review checklist was created to determine how participants used technology in their classroom teaching.

Interviews

Open-ended and face-to-face interviews were conducted 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. The semi-structured interview prompted discussion with the participants and provided an opportunity for the researcher to explore particular themes or further responses in the study.

During the interviews, each of the participants in the study declined the use of audio recorder to record their interviews; therefore, written notes were taken on all participants' responses or statements. After writing down each of the participants' interviews, member checking was used 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. All the 12 teacher participants checked the interview findings for accuracy of their data and returned the interview transcript to the researcher without correction. All the participants replied that they were satisfied with the researcher's 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 research site. The interviews were conducted for a period of 5 days at the research 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.

Data Analysis

In this qualitative bounded case study, Hatch's (2002) typological analysis model was used to analyze the collected study data. A typological analysis was used 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, p. 30). The purpose of this bounded qualitative case study was to explore 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.

Themes Identified in Data

Four themes were 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, excerpts from the documents and transcripts were selected 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, all 12 teacher participants indicated they used technology in their STEM classes at the research site. Participants used laptop computers, desktop computers, manual projectors, and laptop mobile computer carts as technology instructional tools in their STEM classrooms at the research 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.

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. 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 help my students to learn science content and improve their test-taking strategies in STEM classes. I also integrated technology using the USA Test Prepas 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.

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.

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 STEMclasses. 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 tomulti-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 interactive for our students and helps them to learn content vocabulary in STEMclasses. 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.

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 four themes to emerge.

The results of this research study indicated a need for professional development to train teachers to use the TPACK instructional practices and strategies with available instructional technology tools in STEM classes. PD needs to be 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.

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. A mixed methods study could be used to review the entire research 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 research site.

Another approach that could have been used would have involved changing the sample size. For this study, teachers teaching STEM classes at the research site was the focus. A larger sample size would allow for interviews with teachers at different urban schools.

The research study 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 professional development would be an effective way to educate teachers on how to effectively teach chemistry lessons using technology as an instructional tool in STEM classes. This research study is expected to help the teacher participants to better implement technology into their classroom teaching in the STEM curriculum.

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