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Secondary Mathematics Teachers' Perceptions of the Implementation of E-learning to Increase Students' Mathematics Proficiency

Gladstone Faulknor
Walden University

Walden University

College of Education

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Gladstone Faulknor

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the review committee have been made.

Review Committee
Dr. Christopher Cale, Committee Chairperson, Education Faculty
Dr. Michelle McCraney, Committee Member, Education Faculty
Dr. Markus Berndt, University Reviewer, Education Faculty

Chief Academic Officer and Provost
Sue Subocz, Ph.D.

Walden University
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Abstract

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Gladstone Faulknor

MAT, Mico University, 2010

BEd, Mico University, 2008

Project Study Submitted in Partial Fulfillment

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Abstract

There had been prolonged poor performance of Grade 11 students in the Caribbean Secondary Education Certificate mathematics examinations. The purpose of this basic qualitative study was to explore secondary mathematics teachers' perceptions of the implementation of e-learning to teach mathematics and the support they receive to implement e-learning in the classroom. The technological pedagogical content knowledge conceptual framework grounded this study. Data were collected from semistructured interviews with a purposeful sample of six mathematics teachers implementing e-learning in the classroom with students in a secondary school in Jamaica. Inductive data analysis was used to code the interview transcripts. The main themes that emerged included the benefits and problems of e-learning integration in mathematics, teachers' proficiency in e-learning implementation, barriers to e-learning integration, and e-learning professional development training needed. A three-day blended professional development course was created to stimulate teachers' professional practices and develop self-efficacy in e-learning implementation in their classroom.

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Section 1: The Problem

The Local Problem

The problem addressed in this study is the prolonged poor performance of Grade 11 students in the Caribbean Secondary Education Certificate (CSEC) mathematics examinations. Stakeholders from both e-Learning Jamaica and the Ministry of Education, Jamaica, collaborated and targeted Grade 11 students at the secondary level to improve their performance in the CSEC mathematics examination. The mission of e-Learning Jamaica was to facilitate an electronic learning initiative that included web-based and computer-based learning via virtual classrooms using information communication technologies (ICT). According to Daher et al. (2018), ICT refers to advanced audiovisual technology to enhance communications and data processing. Educators integrate ICT using advanced software on computers and the internet synchronously and asynchronously with learners.

Additionally, teachers incorporate computer-based and web-based instructions in classroom instructions. ICT integration supports teachers and helps students explore scientific relations (Daher et al., 2018). Among other key stakeholders, the government of Jamaica has been concerned with the quality of mathematics instruction in schools due to the prolonged poor performance of Grade 11 students in final examinations. As a result, in collaboration with e-Learning Jamaica, the government agreed to implement the e-learning mathematics initiative to improve the Grade 11 CSEC mathematics examination performance.

Problem Statement

The problem addressed in this study is the prolonged poor performance of Grade 11 students in the CSEC mathematics examinations. The statistics department of the Ministry of Education, Jamaica, is responsible for publishing data for each academic year for all education levels in Jamaica. Also, the Caribbean Examination Council is accountable for the CSEC examinations and uses a 1–6 grading scheme. Grades 1–3 represent a pass, and Grade 1 is the highest. Smalling (2019) reported that 48% of the Grade 11 cohort in Jamaica who sat for the general proficiency CSEC mathematics examination in the 2012–2017 academic years achieved Grades 1–3. Over these 6 years, students receiving a Grade 1 averaged 13%, Garde 2 averaged 13%, and Grade 3 averaged 22%.

Galindo and Newton (2017) stated that the efficient use of technology in mathematics develops students' problem-solving skills and may achieve targeted expectations. Additionally, Galindo and Newton suggested that technology used in mathematics cannot be used in isolation but must be related to the user (student and teacher), the environment (the institution), and the task. Also, the e-learning curriculum can enhance learning. However, there is a gap in professional practice because very little is known about how the teachers in their mathematics courses use the mathematics e-learning initiative in mathematics pedagogy (see Galindo & Newton, 2017).

Rationale

The local Ministry of Education, Jamaica, introduced the e-learning mathematics initiative in classrooms to improve success in CSEC mathematics since 2011. However, findings after 2011 mirrored similar conclusions of consistently low mathematics proficiency. Smalling (2019) reported that the percentage of Grade 11 students who passed CSEC mathematics in Jamaica from 2012 to 2017 was 39%, 35%, 56%, 59%, 43%, and 56% respectively. The average pass rate for this period was 48%. Table 1 presents the National Education Inspectorate (2020) report summary of Grade 11 students' CSEC mathematics 2010-–2014 pass rate for the local setting.

Table 1

Grade 11 Students' CSEC Mathematics Pass Rate for the Local Setting

Year	Pass rate
2010	7%
2011	0%
2012	11%
2013	4%
2014	27%

Note. From "Cycle 2 school inspection report," by the National Education Inspectorate (2020).

The National Education Inspectorate (2020) rated the school selected for the current study as unsatisfactory in CSEC mathematics and their overall mathematics progress. Over 5 years (2010–2014), CSEC mathematics students for this school showed a low percentage of passes. In 2010, two students passed (7%), 2011 had zero passes, 2012 had six passes (11%), 2013 dropped to two passes (4%), and 2014 had nine passes (27%) (National Education Inspectorate, 2020, p. 49). Recent trends in CSEC mathematics passes in Jamaica evoked discussions by Bourne (2019) that CSEC mathematics performance is weak and is currently a concern for the Ministry of Education, Jamaica. In recent years, the school principal also confirmed low CSEC mathematics passes and indicated e-learning initiatives (Head Teacher, personal communication, June 19, 2020).

Additionally, Lazarev et al. (2019) asserted that students' achievement using the Alabama Mathematics, Science, and Technology Initiative depends on a technological initiative in mathematics supported by teachers' professional development and school support with classroom practice. According to Lazarev et al., the effect of the Alabama Mathematics, Science, and Technology Initiative on mathematics problem solving was positively and statistically significant in mathematics problem-solving skills. Also, students' mathematics test scores increased compared with the control who did not receive the Alabama Mathematics, Science, and Technology Initiative. The purpose of this project study was to explore secondary mathematics teachers' perceptions of their implementation of e-learning to teach mathematics and the support they receive to implement e-learning in the classroom (see Lazarev et al., 2019).

Definitions

Blended learning: Blended learning is an innovative concept that embraces the advantages of both traditional teaching in the classroom and ICT-supported learning, including both offline learning and online learning (Fuller, 2021). Blended learning is an active instructional strategy that allows for active learning, student centeredness, and student engagement. Additionally, blended learning will enable learners to use resources to build their knowledge and skill development (see Heinerichs et al., 2016).

Basic qualitative research (BQR): BQR is motivated by the researcher's intellectual interest in a phenomenon to extend knowledge. The BQR's primary purpose is to know more about a phenomenon but eventually inform practice (see Merriam & Tisdell, 2016). Constructivism is the framework for the BQR and focuses on the construction of ideas rather than exploring. The BQR also allows the researcher to focus on (a) how people interpret their experiences, (b) how they construct their worlds, and (c) what meaning they attribute to their experiences (Patton, 2015). The purpose of the BQR is to understand how people make sense of their lives and experiences (see Merriam & Tisdell, 2016). Additionally, Patton (2015) described the BQR as contributing to fundamental knowledge and theory.

Caribbean Secondary Education Certificate (CSEC): The CSEC is an examination developed by the CXC to assess students' academic skills. This examination is offered twice each year for both private and in-school candidates. The resistance occurs in January and regular entries in May and June of the same year. Students' general and technical proficiencies on CSEC subjects are assessed using a 6-point grading scheme in which Grades 1, 2, and 3 are considered passes (see Smalling, 2019).

ICT integration: ICT integration is the use of computer-based and web-based instructions in classroom pedagogy. ICT integration supports teachers in their instructions and assists students in their explorations of scientific relations. The combination of ICT in the classroom encourages teaching and learning in Grades K–12. Development in the quality of teaching and learning results from modeling interactive pedagogical approaches through technology. A conducive learning environment happens when collaboration and active learning occur in the classroom (see Daher et al., 2018).

Mathematics proficiency: Mathematics proficiency relates to people's behaviors and dispositions toward solving mathematical problems and has five intertwining strands: strategic competence, conceptual understanding, procedural fluency, adaptive reasoning, and productive personality. Students' must understand concepts, operations, and relations and express flexibility, accuracy, and efficiency in implementing appropriate procedures. Moreover, the learner will formulate and solve mathematical problems, think logically about concepts and conceptual relationships, and have positive perceptions about mathematics (see Liljedahl et al., 2016).

Technological pedagogical content knowledge (TPACK): TPACK is a framework that provides practical, empirical, and theoretical considerations for the integration of technology in the mathematics classroom. The framework links three pieces of knowledge (content, technological, and pedagogical) to form seven knowledge domains. The TPACK encourages effective technology integration and requires teachers to be proficient in the content, technological, and pedagogical knowledge to deliver their courses (Young, 2016).

Significance of the Study

This study was vital to the local setting because it would provide findings to guide school administrators' decision making regarding e-learning instructions used in CSEC mathematics classes. According to Alhashem et al. (2017), teachers who implement e-learning in classrooms should understand teachers' pedagogical knowledge and skills in their practices. From my findings, professionals within the local setting may provide teachers with opportunities to implement the mathematics e-learning initiative.

CSEC mathematics teachers may benefit from the study’s findings if they can reflect on ways to mitigate challenges and barriers to e-learning in their mathematics courses. Students may benefit from introducing technology integration in their mathematics lessons by their teachers to improve learning. Developing problem-solving skills may enable students to increase their mathematics proficiency and pass CSEC mathematics.

Research Questions

Little was known about how secondary mathematics teachers implement the mathematics e-learning in the classroom The purpose of this basic qualitative study was to explore secondary mathematics teachers’ perceptions of their implementation of e-learning to teach mathematics and the support they receive to implement e-learning in the classroom. The following research questions guided the study:

1. What are secondary mathematics teachers’ perceptions of their implementation of e-learning to teach mathematics?
2. What support do teachers perceive is needed for secondary mathematics teachers to implement e-learning in the classroom?

Review of the Literature

The strategy used to search for literature included the Walden University Library, Educational Resources Information Center (ERIC), SAGE full-text database, and ProQuest. The educational databases chosen for the literature provided both peer-reviewed and relevant journals to support the broader problem addressed in the study. The keywords and phrases used to locate and download journals from the Internet and or through Walden University library included *qualitative research*, *instructional practices*, *mathematics proficiency*, *ICT in mathematics instructions*, *TPACK in mathematics instructions, implementing the technological-based program in mathematics, teachers' perceptions of technology in mathematics instructions*, and *ICT interventions in mathematics*.

This section includes a review of the professional literature on integrating technology in the classroom in mathematics pedagogy. Topics of discussion include the e-learning mathematics initiative and the instructional approaches used in its implementation. I reviewed the professional literature to discuss similar and equivalent mathematics initiatives and integrate them into mathematics lessons. I also reviewed professional literature to address barriers to integrating technology, solutions to these identified barriers, and technology integration to support students. Before presenting the literature on technology integration, I discuss the conceptual framework, TPACK, which provided the foundation for this study. I constructed an essential understanding of the responsibilities, challenges, and best practices of integrating technology in mathematics education by conducting this review.

Conceptual Framework

This subsection includes a summary of the literature on the conceptual framework (TPACK) that grounded this study. I include a description of the TPACK, logical connections among crucial elements of the framework, and TPACK's application to the BQR. Additionally, I explain the framework's application to the research questions and methodology.

Conceptual Framework That Grounded This Study

The conceptual framework that grounded this study was the TPACK. The TPACK conceptual framework creates an intersection among technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) that ensures teachers' readiness to teach mathematics using technology (Young, 2016). The framework guides teachers' understanding of multiple representations of concepts using technologies: (a) constructive pedagogical techniques that solidify the use of differentiated instructional technologies meeting students' needs, (b) knowledge of barriers to students' comprehension of mathematics addressed with the help of technology, and (c) knowledge of using technology to scaffold students' content knowledge (see Young et al., 2019). According to Padmavathi (2016), the framework balances theoretical, technological, and practical knowledge, enabling teachers to design mathematics lessons using technology.

Description of the Conceptual Framework

Successful technology integration is grounded in curriculum content and a content-related learning process coupled with educational technologies. According to Park and Hargis (2018), there is a relationship among teachers' knowledge of content, pedagogy, and technology knowledge to integrate educational technologies into instructions effectively. Additionally, to effectively combine instructional technologies into instruction, teachers must plan at the node of curriculum requirements, students' learning needs, available and affordable technologies, and the school and classroom context's realism. Similarly, Goradia (2018) argued that the TPACK conceptual framework core includes learning, skills, and pedagogy. Students learning should involve higher order thinking skills to solve complex problems. Higher order skills in this context include creativity, critical thinking, collaboration, and lifelong learning.

Self-efficacy is important for students’ motivation to learn mathematics, and it reflects confidence in the students’ ability to exert control over their behaviors. According to Bandura (1977), self-efficacy can positively improve students’ motivation in mathematics lessons and increase their academic performances. Additionally, teachers’ knowledge of the technology program’s objectives of the framework seeks to improve their TK, PK, and CK, which guide the process toward effective technology integration through instructions within the specified program (see Bas & Senturk, 2018). Akturk and Ozturk (2019) and Padmavathi (2016) argued that classroom instruction must be practical, and teacher training in technology integration can enhance the mathematics learning environment. Additionally, Akturk and Ozturk argued that teachers’ knowledge and effective technology integration in the 21st century classroom must align with the TPACK model.

According to Kurt (2018), technological tools must instruct and guide students toward a better and more robust subject knowledge and encourage the best use of specific technological devices in the classroom. Also, the content and pedagogy must form the foundation for effective technology integration. This explanation is vital because technology implementation must communicate the content and support the pedagogy to encourage students’ learning. Kurt argued that educational technologies might work with students’ prior knowledge to strengthen their existing epistemology or develop new ones.

TPACK Key Elements

The TPACK conceptual framework development came from connecting the key elements of TK, CK, and PK. In a scholarly discussion, Akturk and Ozturk (2019) argued that TK refers to knowledge that includes advanced technologies such as the internet and digital videos. TK also provides traditional technologies such as chalkboard, chalk, and books. Finally, Akturk and Ozturk posited that CK explains teachers' required knowledge to teach within their disciplines (2019).

The development of the TPACK conceptual framework is grounded in the pedagogical content knowledge concept, and the consideration is that the pedagogical content knowledge concept is an essential requirement for teachers. According to Goradia (2018), teachers need to integrate pedagogical content with their knowledge of technology to deliver better learning outcomes. Padmavathi (2016) presented a complex interactive diagrammatic chart linked to the TPACK domains. Padmavathi showed the connection of TK, CK, and PK. According to Goradia, CK is the teachers' grasp of the subject content, including scientific facts, theories, evidence-based reasoning, and discipline-specific practices. Additionally, PK refers to the teachers' knowledge of teaching and learning. Finally, TK involves understanding technologies suited for information processing, communication, and problem solving.

TPACK Conceptual Framework and Basic Qualitative Research

The purpose of this basic qualitative study was to explore secondary mathematics teachers' perceptions of the implementation of e-learning to teach mathematics and the support they receive to implement e-learning in the classroom. I used TK, PK, and CK to address the research questions in this study. The TPACK conceptual framework guided the basic qualitative study. I used qualitative data to explore the implementation and instruction within the e-learning mathematics initiative. I used the TPACK when reviewing participants' interview responses. According to Valtonen et al. (2020), new technologies in education pedagogy allow educators to recognize and debate each technology's application using the TPACK conceptual framework.

TPACK Conceptual Framework and Research Questions

The mathematics e-learning initiative encompasses advanced audiovisual technologies in mathematics pedagogy, while the TPACK focuses on the effective use of technology in pedagogy. The research questions in the current study connected the conceptual framework and the e-learning mathematics initiative. This connection occurred by capturing teachers' perspectives of e-learning to teach mathematics. Teachers' knowledge of integrating technology in mathematics instruction was needed to implement and teach e-learning mathematics. Basquill (2018, p.98) noted that the TPACK conceptual framework elicits teachers' perspectives based on their experiences and involvement with technology integration and requires a link between technology, pedagogy, and content.

TPACK and Instrument Development

I used a preexisting interview protocol and a researcher's journal for data collection. According to Wang et al. (2015), semistructured interview questions would give an insight into secondary teachers' knowledge and experiences teaching with e-learning. The TPACK interview protocol would also help link mathematics teachers' practices and the TPACK conceptual framework. The preestablished interview protocol had items relating to teachers' knowledge of teaching and e-learning (Townsend, 2017, pp. 263-264) and was modified to suit the current study's context. Townsend's dissertation protocol featured iPads, so I modified this item. The interview questions were developed to explore issues that included how students use technology to learn, how teachers use technology to aid instruction, how the school's structure adapted to meet the needs of technology, and how often technological devices were used for instructional purposes. I also modified Townsend's interview protocol to glean information specific to e-learning in mathematics instruction. The questions addressed the technology available at participants' school, the technology used in mathematics instruction, and how participants use the technology.

TPACK and Data Analysis

I used the TPACK to analyze interview data and confirm or refute the themes. During the inductive data analysis process, I used the three main domains from the TPACK model: TK, CK, and PK. According to Saldaña (2018), an inductive data analysis allows the research findings to emerge from themes inherited from raw data without the restraints of structured methodologies. During the coding process, I coded data for TK, PK, and CK to explore data specific to integrating technology in content and pedagogy. Young (2016) explained that the emergence of themes in the data should highlight concepts, actions, and relationships relative to participants' perceptions. Teachers' interview responses were coded to describe and demonstrate TK, PK, and CK.

Review of the Broader Problem

Little was known about how teachers in mathematics courses use the mathematics e-learning initiative in mathematics pedagogy. I expanded on the implementation of the e-learning mathematics initiative and the supporting instructional approaches. I also aligned the e-learning initiative with the TPACK conceptual framework and other e-learning mathematics programs currently used in mathematics pedagogy.

E-learning Mathematics Initiatives and Instructional Approaches

E-learning mathematics initiatives are technological tools used to improve instructional pedagogy in the classroom, and their use and purpose should exist as common knowledge among all clients involved. The objective of the Jamaican schools' e-learning mathematics initiative is to increase mathematics proficiency at the CSEC mathematics level and embrace several strategies to ensure effective mathematics pedagogy (see Linton, 2016). Linton argued that mathematics teachers use e-learning mathematics to differentiate their lessons, spiral curriculum, personalize instructional systems, and provide whole-class interactive teaching to improve students' mathematics achievement. A well-prepared and differentiated lesson appropriate for the learning needs and difficulties in the classroom, which Bal (2016) argued encouraged learners to achieve higher scores in the scope of measurable mathematics success.

According to Bowman (2018), the spiral curriculum is a learner-centered and reliable foundation upon which to build a model for student learning. Bowman also discussed the spiral curriculum to allow relevant learning with ongoing formative assessments to monitor students' process. These curriculum elements foster learner autonomy, a transferable learning skill needed for life. The employment of a personalized instructional system could keep students active and improve their self-confidence and mathematics proficiency. According to Basham et al. (2016), a personalized instructional system allows for pace and varied activities for students based on their present understanding and proficiency in a mathematics lesson. Additionally, a customized instructional system will enable teachers to meet all learners' needs effectively. Also, through technology, the design of learning environments creates an opportunity for students to learn at their own pace.

Whole-class interactive teaching is also an instructional strategy of the e-learning mathematics initiative that allows students to learn from others and offer their support. Additionally, students enjoy an active pedagogical approach through the idea of whole-class interactive teaching. The concept of whole-class interactive teaching is perceived to positively impact students' learning and enjoyment (see Basham et al., 2016). The best way to improve knowledge is to improve teaching, which requires constant reflection on teaching strategies and the classroom environment (see Achen & Lumpkin, 2015). The e-learning mathematics initiative employs differentiated lessons, a spiral curriculum, a personalized instructional system, and whole-class interactive teaching strategies in the mathematics intervention targeted at students with low CSEC mathematics proficiency (see Linton, 2016). Linton as argued that teachers embrace the blended learning curriculum to sustain mathematics instructional pedagogy through the e-learning mathematics initiative with these strategies in place.

E-learning Mathematics Initiative and the TPACK Theoretical Framework

Another e-learning mathematics initiative has included the TPACK conceptual framework to explore implementation and instruction within mathematics programs. According to Mutlu et al. (2019), the VuStat is a technological program that facilitates teaching statistics and probability in mathematics to students at different levels. “Vu” stands for visual vocabulary, and “Stat” represents statistics. Additionally, teachers use the VuStat to develop appropriate instructions to teach relevant mathematics content to K–3 students. Teachers presented their lesson plan incorporating VuStat for peer evaluation following the training (see Mutlu et al., 2019).

Another program that used the TPACK conceptual framework is a mixed-methods evaluation of the statewide implementation of mathematics education technology for K-12 students (see Brasiel et al., 2016). The study focuses on using computers, software programs, and the Internet to deliver mathematics content to enhance students’ mathematics learning. Also, the mixed-methods evaluation method could use the TPACK conceptual framework to explore teachers’ knowledge of implementing technology in their classroom. Additionally, the TPACK conceptual framework tracks teachers’ mathematical TPACK, their experiences, and feelings while teaching mathematics using technology. It is imperative to note that the TPACK conceptual framework used major themes in tracking teachers’ skills which guide the findings of the study. Themes discussed in this mixed-methods evaluation research included curriculum and assessment, learning, instructions, and access.

The mixed-methods evaluation research focused on integrating technology in mathematics instructions and using the TPACK conceptual framework to examine mathematical software. Mathematical software used in the classroom includes but is not limited to GeoGebra, Cabri, and Geometers Skeptpad. According to Muhtadi et al. (2017), this study used the TPACK conceptual framework to conduct peer reviews and open discussions to harvest teachers' perspectives of technology-based teaching consistent with the ICT-TPACK criteria. Also, Muhtadi et al. argued that the ICT-TPACK measures include the identification of (a) the appropriate topic of teaching using technology, (b) the adequate representation to change content, (c) teaching strategies that are not compatible with traditional pedagogy, (d) the right integration strategy, and (e) selecting the right tools and pedagogical use of their capabilities (2017).

The use of the TPACK conceptual framework in technology integration in mathematics instructions produced findings that suggest a positive impact for both teachers and students. Additionally,), positive implications for students and teachers include developing mathematics understanding, preparing, and enhancing TPACK competencies. The use of the TPACK conceptual framework in the study demonstrated its worth in allowing researchers to note the relationship between technological mathematics programs, the positive impacts of appropriate instructions that facilitate mathematics efficacy among teachers and students, and the development of mathematics proficiency. After analyzing mathematics programs using the TPACK conceptual framework, the discussion on equivalent programs focuses on programs like the e-learning initiative (see Muhtadi et al., 2017).

Equivalent Programs to the E-learning Mathematics Initiative

There are several programs equivalent to the e-learning initiative. These include the Please Go Bring Me-Conceptual Model-Based Problem Solving (PGBM-COMPS) intelligent tutor program for students with learning difficulties, the E-learning mathematics program, the basis for a mathematics intervention program, and the Trial intervention mathematics. According to Xin et al. (2016), the Please Go Bring Me-Conceptual Model-Based Problem Solving (PGBM-COMPS) intelligent tutor program seeks to enhance the multiplicative problem solving of students with learning difficulties (LDs) in mathematics. The PGBM-COMPS mirrored the e-learning mathematics initiative with a focus to improve students' mathematics abilities through improved ICT instructions and interactions in the learning environment. Additionally, the PGBM-COMPS, as with the e-learning mathematics initiative, selected participants based on a school identification of students experiencing substantial mathematics problems and scoring low percentile in mathematics assessments. The PGBM-COMPS draws on three research-based frameworks that generalize word problem underlying structures from special education. These research-based frameworks include a constructivist assumption of learning from mathematics education, data learning from computer science, and conceptual model-based problem solving. Subsequently, Xin et al. confirmed that the PGBM-COMPS generalizes students' understanding of multiplicative reasoning, allowing their thinking process to go beyond concrete and symbolic representations to abstract mathematical models that depict a mathematical relationship within the problem (2016).

Higgins et al. (2016) used action research to gather qualitative findings on the use of an e-learning mathematics program in an urban Jamaican school. The e-learning mathematics program focused on low achieving students to improve their CSEC mathematics achievement. Here, Higgins et al. assertions coincide with Bal (2016) arguments for increasing students' mathematics proficiency through E-learning pedagogy. Additionally, the E-learning mathematics initiative seeks to effect positive change and build students' capacity for critical thinking in mathematics.

Another technological mathematics initiative that seeks to improve students' mathematics proficiency is the Basics mathematics intervention program. The program enables low achievers to attain improved mathematics achievement and successfully transition to core mathematics (see Higgins et al., 2016). Also, the program seeks to improve the automaticity and accuracy of recalling basic mathematical facts, rules, concepts, and procedures. Additionally, the Basics mathematics intervention program linked to the e-learning mathematics initiative concept of the interactions in the learning environment. The arguments in both e-learning mathematics initiatives encouraged mathematics achievement in the learning environment to allow for successful transition in mathematics proficiency.

Ewing (2016) explained that the trial intervention mathematics was designed for teachers to efficiently facilitate low performing students in mathematics in a special education school in Queensland using a blended approach. Similarly, Linton (2016) confirmed teachers' efficiently facilitating students with low mathematics proficiency using a blended approach in their mathematics instructions. The trial intervention program used the reality, abstraction, mathematics, and reflection (RAMR) instructional cycle, connecting conceptual understanding, automaticity, and fluency. The instructional periods of the RAMR provide multimodal forms of learning opportunities. These multimodal forms of learning enabled students to communicate with the realities of mathematics in life and link ideas with contexts within their experiences (see Ewing, 2016). Yenmez (2017) weighed in and confirmed that the e-learning mathematics initiative provides multimodal truths in mathematics using a blended learning curriculum and therefore is like the trial intervention program.

Finally, equivalent programs to the e-learning initiative confirmed several successes. These interventions' successes include providing reliable information for decision making on procedural fluency, progress in student understanding, and mathematics achievement. Additionally, these equivalent programs confirmed the development of conceptual and critical thinking skills among students. Consequently, these programs embrace instructional strategies that form the basis for subsequent discussion.

Integrating the E-learning Mathematics Initiative

This section will review the literature on instructional strategies stemming from the project study problem of prolonged poor performance of Grade 11 students in the Caribbean Secondary Education Certificate mathematics examinations. I discussed ICT in the Jamaican curriculum, student mathematics proficiency, and technology integration in mathematics. I also discussed barriers to e-learning integration and student motivation and engagement.

ICT in the Curriculum

The curriculum now includes ICT as a tool to drive instructions (Ministry of Education Jamaica, 2020). According to several authors (Afzal et al., 2019; Wanjala et al., 2015; Yenmez, 2017), exploring instructional strategies could provide helpful information on the development of critical thinking, students' understanding, and engagement, conceptual learning, and motivation occurring in the classroom. In a subsequent discussion, these authors encourage instructional strategies in the e-learning mathematics initiative to foster improved mathematics proficiency among learners. Additionally, Yenmez argued that teachers have technological tools at their disposal, such as virtual manipulative, educational software, computers, Yenmez also posited that teachers should integrate interactive whiteboards, and the internet into their mathematics lessons to improve students' mathematics proficiency.

Student Mathematics Proficiency

The school and teachers are responsible for enhancing students' mathematics proficiency with technology. In further discussion, Yenmez (2017) posited that various students' learning and critical thinking skills might be developed by adapting technology in mathematics lessons. Subsequently, Yenmez argued that multimedia tools particularly important for the development critical thinking in mathematics. These multimedia tools include but not limited to audiovisual presentations and 3-D shapes aids. These multimedia tools function as productivity tools in mathematics instructions to boost students' understanding and engagement. As a result, technology used in mathematics helps students overcome their conceptual learning and problem-solving difficulties (see Yenmez, 2017).

Technology Integration in Mathematics

The effective use of technology in mathematics instructions to construct learning environments could help students be active learners. Additionally, computer-aided instructions become relevant in correcting students' alternative conceptions. Yenmez (2017) explained that this alternative conception could be identified and addressed using technology in a blended instructional approach and students' difficulties. In a subsequent discussion, Wanjala et al. (2015) confirmed that the effective use of computer-based guidelines in mathematics builds on students' positive attitudes, motivation, and achievement. Additionally, Yenmez argued that virtual manipulation is a technology tool that effectively develops students' mathematics proficiencies and the teachers' ability to know when and where to use technology. The discussion of instructional strategies in mathematics pedagogy clinically focused on the benefits of inspirational instruction through technological tools to enhance students' mathematics proficiency. This instructional approach could encourage student motivation and engagement within the e-learning mathematics initiative (see Yenmez, 2017).

External Barriers to Technology Integration

According to Jacovina et al. (2016), there are barriers to technology integration in the classroom. External challenges may include access constraints, inadequate training related to technology, and support constraint. Access constraint is defined as insufficient computers or internet connectivity and may affect the implementation of educational technology. Adequate professional development in technology training for teachers remains vital for technology in the classroom. Jacovina et al also posited that teachers may not use modern technology to their full potential, having received inadequate professional development training in technology. Additionally, support constraint refers to inadequate technical support received by teachers to integrate technology.

Technology Integration. Jacovina et al. (2016) further outlined that effective technology integration needs widespread access to equipment to facilitate educational computer programs. Similarly, Margolin et al. (2019) confirmed that high-quality professional learning training helps teachers integrate instruction that develops and supports 21st-century skills among students. According to Jacovina et al., adequate computer lab time and consistent computer access are vital for educational technology's viability. Additionally, constant computer access with Internet access makes it easier for teachers to integrate technology into existing lesson plans. Also, Margolin et al outlined that a teacher may develop their confidence to implement technology in the classroom through professional development technology training. Technology continually changes, and teachers' technological expertise is relevant to using appropriate new technologies in their lessons.

Professional Development. Additionally, education stakeholders must provide the resources necessary to provide continuous professional development in educational technology. If teachers are using Ipads, special training is needed to make the device useful for lessons. Crucially, schools may source ongoing professional development training from an external organization. Technology training from external organizations could help teachers address student standards, train teachers' means, and evaluate students' standards. Jacovina also outlined those teachers worry less about technology barriers when they receive additional technical support. High-quality technology support from creators of educational technologies and school employees could help teachers access resources for their lessons and increase acceptance of classroom technologies.

Internal Barriers to Technology Integration

Internal barriers to technology integration may include teacher attitude and beliefs, confidence in skills and knowledge, technology and learning, and teacher resistance to technology in the classroom. Jacovina et al. (2016) explained that teachers' attitudes and beliefs influence how teachers implement the technology. Teachers may not have prior technological experience and feel intimidated. Teachers feeling intimidated may have less class control, use less technology, and refuse to explore innovative technologies in their instructional practice. Instead, teachers will use traditional teaching methods where they feel they have more control.

Teachers may use their philosophy to determine how students learn. Teachers will use the traditional chalk-and-talk approach to regard students learning styles as explicit instruction. In contrast, if teachers are aware that their students, they can reliably access technological tools, and are likely to plan lessons that incorporate technology (see Margolin et al., 2019). Teachers who drive classroom activities using traditional methods suggest they use less integration of computer-based technology in classrooms. Teachers may also have resistance to technology in the classroom. Integrating technology into lessons can be exhausting and may demotivate teachers using technology. Teachers need to learn the technology they want to use before incorporating it into the classroom objectives and curriculum. Additionally, Jacovina et al. argued that teachers may doubt various technological tools available online due to their uncertainties of the effectiveness of these technologies.

Student Motivation and Engagement

This section will discuss literature related to student motivation and engagement in the e-learning mathematics initiative. The knowledge of students' motivation and engagement are important to my study since they allow for an understanding of students learning experiences and what stimulates their achievements. They are also important since they provide a link between students' learning and the use of technology. Also, motivation and engagement are vital topics since they explain how students' functional capabilities lead to active classroom participation. I will begin by discussing student motivation and conclude with student engagement.

Student Motivation. Students' useful striking characteristic is a precondition for learning, and the use of technology simulates this characteristic and encourages students' motivation. According to Afzal et al. (2019), the initiative geometric function approach has the prospect of efficiency in increasing students' motivation for achievement goals in mathematics and allows students to reconstruct their learning experiences. It is important to note that students with high motivation are more successful than students with low motivation. Murphy (2016) also confirmed an increase in motivation to learn among students using technology. In further discussion, Murphy explained that technology encourages students to feel more comfortable learning mathematics. It becomes essential for the students to develop a deeper understanding of mathematical concepts.

Additionally, Garcia-Santillán et al. (2016) weighed in and confirmed technology used in mathematics encourages motivation among students. In their discussion, students with high motivation toward mathematics enjoy resolving mathematical problems and endeavors until they solve them. Also, motivated students think of mathematics outside the classroom and become absorbed in their mathematical activities. Furthermore, Garcia- Santillán et al. argued that weakly motivated students may dislike mathematics challenges. Spending time on a problem frustrates poorly motivated students, and they prefer receiving the answers to the mathematical question instead of trying to solve it independently.

The use of technology in secondary school can help motivate students in mathematics. According to Gökçe et al. (2016), the rapid ICT consumption in mathematics teaching and learning improves students' motivation, allowing for greater appreciation, thinking, modeling, and problem-solving in mathematics links to Garcia-Santillán et al. (2016) assertions. Similarly, technology in mathematics could motivate students' algebra and causes students to show greater appreciation than in a non-technological mathematics classroom (traditional classroom) (see Graziano & Hall, 2017). The use of technology in mathematics instructions expands students' motivation to do well in mathematics. Technology encourages students' engagement in the subject matter, as Kim et al. (2020) explained in subsequent discussions.

Technology integration can develop students' higher-order thinking skills and support their learning. According to Kim et al. (2020), students become active learners through mobile technology integration. Engaged learners are said to be self-directed and involved in the learning process and develop the ability to analyze and synthesize ideas. Additionally, they will also be able to make judgments and apply theories. The integration of mobile technology is said to facilitate students' affective aspects. Kim et al. explained that students who continuously use technology increase their participation rates in the classroom, increase their interest in learning, and motivate them to perform in the teaching and learning environment. Students may also engage in collaborative activities using communication tools and demonstrate better academic outcomes.

Similarly, technology integration in the teaching and learning environment can also support secondary students with autism. Hedges et al. (2017) asserted that benefits resulting from technology integration help autistic students to increase their independence, enhance their social opportunities, and relieve their anxiety and stress. The authors explained that technology use helps these students to address areas of need resulting in increased independence. Students can address their requirements by using a laptop in class to copy notes, manage and track documents, or use the Internet to find answers to questions. Students may develop their social opportunities with a variety of social media platforms. Students' interactions with their peers online through video conferencing or texting could make it easier for them better to understand their peers' current affairs and understanding. Subsequently, Hedges et al. confirmed that technology use could support effective communication among students and their peers. The technology could also help students reduce anxiety and stress by listening to music and playing educational video games.

Student Engagement. Students' continuous exposure to various technological initiatives can motivate them to learn mathematics and encourage their engagement in mathematical activities offered through the mathematics e-learning initiative. Engagement in mathematics refers to students' psychological investment in their effort directed forward, knowledge, mastering of experience, or skills that academic work is intended to promote. Iji et al. (2018) noted that using technologies in mathematics, such as mathematics video games that situate and integrate academic content with gameplay, allows increased student engagement. The e-learning mathematics initiative offers various technologies, but instructions are vital to student engagement.

Iji et al. (2018) categorized student engagement into affective and behavioral components when using cloud mathematics services. Iji et al. also argued that active engagement relates to students' interest and enjoyment of mathematics. In contrast, students' behavioral engagement refers to active academic and social activities. Consequently, the e-learning mathematics initiative must foster affective and behavioral engagements to solidify their ability to improve mathematics. Subsequently, stakeholders of the e-learning mathematics initiative must understand the impact of students' active engagement as it directly affects the intensity and continuity of engagement in the learning process of mathematics, the selection of instructional strategies, and the depth of understanding needed for improved mathematics proficiency. According to the Iji et al., behavioral engagement in mathematics refers to students' ability to manage their learning by choosing appropriate learning goals, using their prior knowledge, and employing critical thinking skills to solve a mathematical scenario. To do these well, students must endeavor to be self-directed and overcome their difficulties. Finally, the adaptation of the technology to mathematics cloud service resulted in students feeling good, thinking critically, and actively participating in their mathematics learning (see Iji et al., 2018).

The proliferation of digital technology in the mathematics classroom can only improve mathematics proficiency among students through engagement. Educators use various online tools in mathematics pedagogy. According to Erdem (2017), assistive technology (AT) improves mathematics and pedagogy and raises students' achievement. AT is a technology or teacher-made product designed to enhance students' functional capabilities. Mathematicspad plus, Viewplus accessible graphing calculator, portable calculator with talking multiplication table, and MathematicsTalk are ATs used in mathematics pedagogy that improves behavioral, cognitive, and emotional engagement among students' users. Unlike Behavioral and emotional engagement, explained by Iji et al. (2018), cognitive engagement refers to students' ability to incorporate thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and difficult skills (aee Erdem, 2017). In further arguments, Erdem posited that ATs encourage students' independence and increase their participation in classroom activities and their wider community.

Additionally, Erdem argued that the use of ATs facilitates students' engagement in solving mathematics problems, reading, writing, interpreting worded questions, and building their social interactions in the classroom. Also, using ATs enhances all students' success with various disabilities. The learning paradigm of mathematics shifted as it now facilitates multiple forms of digital technologies in classroom pedagogy that increase students' quality of learning environments to motivate and engage (see Erdem, 2017).

Multicultural Education, Connective Intelligence, and Instructional Delivery

This section will discuss literature related to multicultural education, connective intelligence, and instructional delivery and their link to my study problem. These topics relate to my problem since they explain students' benefits when technology facilitates mathematics pedagogy. They are also vital since they demonstrate how the e-learning mathematics initiative could promote cross-cultural communication skills, meaningful learning, motivation, and engagement and build evocative capacity. Additionally, the topics are relevant since they explain how the e-learning mathematics initiative's instructions could bridge the gap between the blended learning curriculum and the CSEC mathematics assessment. I discussed scaffolding, covered connective intelligence, and concluded with instructional deliveries.

Teachers Scaffolding Students' Learning

Scaffolding is a platform appropriate for instructional delivery and aligns with multicultural education. According to Cho and Cho (2016), scaffolding is instructional support by which experienced individuals help students maximize their full potential to improve their subject proficiency. Instructors using e-learning for instructions may use scaffolding strategies to encourage students' engagement in a virtual setting with peers, content materials, and instructors. Additionally, Cho and Cho argued that instructional delivery through scaffolding gives credence to students feeling connected in the course, belonging within the virtual setting, and the opportunity to pace their learning. Consequently, students' connection in the class could develop their critical thinking skills and proficiency in mathematics, for which the discussion on connective intelligence will expand (2016).

Connective Intelligence

Connective intelligence is an important attribute needed for human development. According to Novo et al. (2017), students' mathematics proficiency improves when integrating connective intelligence. Connective intelligence is also significant in students' decision-making, solving problems, processing data, and understanding the environment. Early development of connective intelligence is linked directly with active learning and memory development. Accordingly, to encourage improved mathematics proficiency, the e-learning mathematics initiative used in mathematics pedagogy and classroom activities should allow visual, auditory, tactile, and olfactory stimuli instead of abstract.

Mathematics concepts build on each other, progressing from simple to the most complicated concepts. According to Higgins et al. (2016), students' ability to make mathematics connections expands their evocative capacity and fixes concepts firmly in long-term memory. In further discussions, students remember these concepts with greater clarity and simultaneously recuperate conceptual relations efficiently, resulting from connections in the memory footprints. Noting that connections link knowledge to everyday life experiences, teachers could use the e-learning mathematics initiative to develop an in-depth understanding of varying types of relationships and creative ways of developing them with their students. Also, Higgins et al. argued that developing relationships among students and the concepts they learn must support good instructional deliveries through the e-learning mathematics initiative in the classroom (2016).

Instructional Techniques in Mathematics

Students in the classroom need inspirational instruction by integrating appropriate instructional technologies. Success in mathematics depends on students' interests and motivation, which develop internally and are sometimes influenced by external factors (see Tambunan, 2018). To bridge the curriculum and assessment gap, instruction occurring within the mathematics e-learning initiative must encourage intrinsic and extrinsic motivation among students in mathematics lessons. Accordingly, teachers must design and use instructional techniques to deliver the curriculum objectives, comfort the learning, and use diverse learning approaches to motivate students to develop their mathematics abilities (see Mutlu et al., 2019).

Consequently, Tambunan (2018) suggested the need for the e-learning initiative to develop students' intrinsic motivation for mathematics to improve CSEC mathematics assessment performances. Additionally, teachers could convey learning by the students' intellectual level to generate the learning interest and explain the importance of learning to foster mathematics motivation. In further discussion, the teacher should use excellent instruction to teach the lesson content and ensure that the lesson's success and design boost students' achievement. The author also emphasized students' need to enjoy their mathematics lessons since there is a relationship between learning pleasures with learning achievement. Also, there is a need for instructional techniques to encourage targeted students' intrinsic motivation, raise awareness during the learning process, re-examine students to improve scores and provide feedback. Instructional deliveries containing these criteria encourage students to develop a willingness to learn, improve learning motivation, and create a stimulus for students in the lesson (see Tambunan, 2018).

Similarly, Furner and Worrell (2017) posited that students' learning process differs. Teachers should make explicit connections between manipulative, mathematical ideas, and verbal interactions to promote understanding by diversifying instructional strategies and learning tasks. Consequently, the reform-based instructional method influences students' mathematics knowledge. Instructional techniques that effectively bridge the gap between the curriculum and assessment could deepen students' motivation, engagement, and learning process during the e-learning mathematics initiative in their learning. Subsequently, appropriate instructional deliveries occurring within the e-learning mathematics initiative could raise students' awareness, retention, and mathematics achievement.

Implications

The project study explored secondary mathematics teachers' perceptions of the implementation of e-learning to teach mathematics and the support they receive to implement e-learning in the classroom. The study's findings may lead to strategies that could help identify strategies that could increase students' pass rates in the CSEC mathematics examination. The research findings may also identify teachers' professional development strategies to improve students' success in online sections of their mathematics courses. Research findings could also increase student retention, persistence, and satisfaction in e-learning versions of their mathematics courses. Finally, other academic areas may also utilize the findings to support success in e-learning and face-to-face classes.

Summary

This section introduced the problem of the prolonged poor performance of Grade 11 students in the CSEC mathematics examinations. This problem is significant to students since it affects their learning outcomes in mathematics. The nature of the problem justifies the basic qualitative research to explore instruction using e-learning mathematics initiatives. Teachers' perspectives would provide data for this exploration. Teachers need effective technology integration to be proficient in the content, technological, and pedagogical knowledge required to deliver their courses. Section 2 will describe the methodology used in this study and present the setting and sample, instrumentation and materials, data collection instruments, and analysis method.

Section 2: The Methodology

Qualitative Research Design and Approach

Section 2 provides information about the research design and approach and the rationale for using a BQR design. I also describe the setting and sample, instrumentation and materials, and data collection and analysis. Additionally, Section 2 focuses on measures taken to protect the rights of the participants in this study. I developed the following research questions to guide the research and investigate the research problem:

Research Questions

1. What are secondary mathematics teachers' perceptions of their implementation of e-learning to teach mathematics?
2. What support do teachers perceive is needed for secondary mathematics teachers to implement e-learning in the classroom?

This subsection includes a discussion of the BQR design in this study. The BQR was relevant for exploring and understanding how mathematics teachers use e-learning mathematics initiatives in mathematics pedagogy. Because of the nature of this phenomenon, qualitative data and findings were needed. The guiding research questions focused on secondary mathematics teachers' perceptions of e-learning to teach mathematics and the knowledge required for secondary mathematics teachers to implement e-learning. Teachers' perspectives vary within an educational setting, making it appropriate to use a BQR. The flexibility of the BQR allowed me to delve into and unpack more complex experiences related to the research questions. Merriam and Tisdell (2016) noted that the BQR is relevant for this type of research. The e-learning mathematics initiative is unique and occurs naturally. Additionally, when researchers use the BQR, it helps them address problems in the field, interpret participants' perceptions and experiences related to a practical problem, and conduct the study in a natural setting (see Merriam & Tisdell, 2016).

Justification of Design

The BQR characteristics aligned with my study's purpose. According to Merriam and Tisdell (2016), qualitative researchers conducting a basic qualitative study are interested in knowing how people interpret their experiences, construct their worlds, and assign meaning to their life experiences. The overall purpose is to understand how people make sense of their lives and experiences. Data collection for basic qualitative studies includes interviews, observation, or document analysis. I used an interview protocol to collect qualitative data aligned with the basic qualitative study characteristics. I was interested in understanding the teaching and learning transaction in the classroom, which aligned with Merriam and Tisdell description of an educational psychologist. Additionally, data analysis addressed recurring patterns that characterized the data and represented the findings. The interpretation of these findings would explain participants' understanding of the phenomenon of interest. My findings were intended to reveal themes to answer the research questions.

Participants

Criteria for Selecting Participants

This study's potential participants included 10 CSEC mathematics teachers using e-learning in their CSEC mathematics courses over the last 3 years. Participants who matched these criteria would constitute a purposeful sample. According to Patton (2015), purposeful sampling is used to select information-rich cases for in-depth study. Information-rich cases are those who have information about a phenomenon of vital importance to the study's purpose. Patton also argued that analyzing information-rich cases yields insights and in-depth understanding. Also, Merriam and Tisdell (2016) confirmed that purposeful sampling is used to promote understanding, discover new knowledge, and gain insight from individuals who have characteristics in common.

Participant Recruitment

To access the school for this study, I emailed the school's principal to introduce myself and attached an invitation letter to conduct my study at the urban secondary school. The principal approved my invitation through a cooperation letter. The school did not provide any data or staff assistance for the study. I selected six teachers based on the following criteria:

- CSEC mathematics teachers who had integrated e-learning in their mathematics classes for at least three years
- licensed mathematics teacher

Upon receiving approval from the Walden University Institutional Review Board (IRB Number 03-24-21-0376242), I contacted the principal of the urban secondary school with the information. Due to COVID-19 restrictions, I met with 10 mathematics teachers through an online staff meeting, and all matched the selection criteria. I spoke to potential participants and outlined the specifics of the study including the requirements for participation. I ensured teachers that their names and details would remain confidential. I provided my email address and phone number for teachers to contact me if they were willing to participate in the study. I replied with a copy of the invitation letter and the consent form via email for each of the six teachers who contacted me. Teachers who wished to participate returned the consent form with the “I consent” selection. Participants received no incentives for their involvement.

Once I received participants’ consent, I emailed participants separately with options for ways, days, and times to meet for the interview. All participants opted for Skype interviews during spring break. During my communication with participants, I gave them the option to select the most appropriate day and time for the interview. I conducted and recorded the interviews with each of the six participants. I used a numbering system to represent each teacher to protect their identity (see Table 2).

Table 2

Participants Pseudonyms and Demographics

Pseudonym	Qualification	Teaching experience
Participant 1	B.Ed. Mathematics Education	15 years
Participant 2	B.Ed. Mathematics Education	17 years
Participant 3	B.Ed. Mathematics	5 years
Participant 4	Master of Arts (MAT) Education	20 years
Participant 5	B.Ed. Mathematics	19 years
Participant 6	B.Ed. Mathematics	6 years

Justification for the Number of Participants

Qualitative research samples tend to be small to support the depth of case-oriented analysis fundamental to a qualitative study. Patton (2015) argued that the fewer the participants, the deeper the inquiry per individual. Additionally, qualitative sample sizes should be large enough to obtain enough data to attain saturation. Also, a small sample should describe the phenomenon of interest and address the study's research questions. (see Patton, 2015).

In the current study, I sampled a homogeneous group of six mathematics teachers implementing e-learning. However, Morse (2015) and Sim et al. (2018) suggested that a small sample size depends on the researcher's level of study. Morse and Sim et al. also argued that the researcher should administer five 1-hour interviews with each participant to achieve redundancy. These assertions aligned with the 23 open-ended interview questions used for my research. Although saturation depends on the sample size, Morse argued that it also connects to the theoretical aspects of inquiry. According to Morse, the theory inquiry considers several skills that the researcher must possess to manage data analysis. Morse further argued that the researcher should have good questioning skills, be sensitive and experienced, know the theory and the literature, interpret data, and identify vital data when working with a small sample. As a result, the researcher learns more about the phenomenon when the analysis spirals from participant to data analysis and back to participants (see Morse, 2015).

Data saturation is a familiar concept employed in qualitative research for estimating sample sizes. A small sample may result in all necessary data needed to answer the research questions in empirical studies. According to Guest et al. (2020), the first five to six interviews produce most of the current information in the data set. Few new details might emerge as the sample size approaches 20 interviews. Additionally, Guest et al. argued that the probability of identifying a concept (theme) among a sample of six individuals is greater than 99% if that concept is shared among 55% of the larger study population. Notably, Guest et al. and Sim et al. (2018) argued that saturation is operational in diverse ways, although it guides data collection and analysis. According to Sim et al., a sample of three to 10 and five to eight for phenomenological and case study research, respectively, is appropriate to achieve saturation, given the sample is homogeneous. A researcher can use a sample of two to 10 participants to achieve redundancy or saturation.

Gaining Access to Participants

I used a cover letter to seek permission to conduct the study and access the local site (see Appendix B). The cover letter explained the purpose of the study, the criteria for potential participants in the study, and the data collection methods. Upon receiving permission from Walden University's IRB, I emailed a consent form to the potential participants to invite their voluntary engagement in the study. The consent form contained the research purpose, procedures for data collection, sample questions, the nature of the study, risk and benefits, payments, privacy, and contacts. Potential participants received an email that welcomed them to participate. I also congratulated participants for their participation selection and asked participants to send the time, date, and location convenient for an interview. Participants could be interviewed in person, by phone, or by Skype, and they were reminded of their consent to participate. The selection letter also explained the transcription process and transcript review. Once teachers volunteered to participate in the study, I organized an interview date and time for in-depth data collection.

Establishing Researcher–Participant Relationship

Although I had the experience of instructing teachers on integrating e-learning in their courses and using e-learning in my mathematics courses, my role as a researcher was objective and unbiased. I respected each participant's confidentiality and privacy to establish a rapport with participants (see Merriam & Tisdell, 2016). Anonymity and participants' confidentiality are vital steps in protecting participants from potential harm. DeVaney (2016) noted that studies with human participants require prior approval from an IRB. I used a pseudonym code to protect participants' identities in the current study. I also considered my study's harm, risk, and benefits to participants, including physical, psychological, social, economic, legal, and dignity harm (see DeVaney, 2016). I selected participants based on the criteria in the cover letter and vowed to keep their information confidential. I stored recorded interviews and transcripts on an encrypted flash drive and secured them in a fireproof locked vault in my house office.

Data Collection

Data collection for this study consisted of interviews with six CSEC mathematics teachers. I sought to address the research questions, the purpose, and the local problem in the study. The intent was to conduct the interviews in the local setting. I was flexible with participants if they preferred phone or Skype interviews.

I used a preestablished TPACK semistructured interview protocol (see Townsend, 2017) for my first data source, and I used a researcher's journal for the second data source. Merriam and Tisdell (2016) posited that a semistructured interview protocol (see Appendix C) might all be flexible or a mixture of structured questions. The interview protocol I used had a list of questions to be asked. The use of a semistructured interview protocol allowed me to respond to the emerging worldview of the respondents' innovative ideas on the topic. The TPACK interview protocol guided my interaction with each participant (see Merriam & Tisdell, 2016).

Interview

The questions listed in Appendix C guided the interview discussion, focusing on the TPACK conceptual framework and the research questions. I used Townsend's (2017) interview questions to guide the protocol. The interview protocol contained questions that would probe mathematics teachers' CK, PK, and TK in the spring term. I prepared the open-ended questions before the interviews and included the same questions for each participating teacher. I recorded the meeting, which lasted up to 1 hour. Carl and Ravitch (2016) noted that interview questions allow researchers to understand participants' experiences. Face-to-face interviews with teachers would produce firsthand knowledge of teachers' perspectives on implementing and instructing e-learning mathematics initiatives in their mathematics courses. I followed the same protocol for participants who engaged in phone or Skype interviews. Teachers selected to participate in the study would receive a selection letter welcoming them to join (see Appendix E). Following teachers' acceptance to join, they would then be interviewed. The interview protocol identified me as a doctoral student and described the purpose of the study.

Before participant interviews started, I thanked each of them for their voluntary participation. Participants were made aware that they could take a break at any time during the interview in addition to a 10-minute break after the first 12 questions. I conducted each interview on Skype and collected journal notes. Each interview was one-on-one, and all data gathered remained confidential. I completed a one-on-one interview with six CSEC mathematics teachers using e-learning in their mathematics courses via Skype and collected journal notes. I endeavored for all data gathered to remain confidential. I recorded each interview and achieved the objective of the study. Teachers provided detailed perceptions of implementing e-learning and the support they needed during this process.

Additionally, teachers became comfortable speaking freely and expanded on each point they made without probing and clarifying questions. According to Carl and Ravitch (2016), organizing different participants' responses allows researchers to create portraits of complicated processes. After collecting the interview data and reflective memos, I developed a data analysis plan that explained how I organized and analyzed the interview data and the journal notes collected. After I conducted the interviews, I coded the data. I used a deductive approach using codes created from crucial elements of the TPACK conceptual framework. These elements included CK, TK, and PK. I expanded the data analysis used in the study, which led to themes' emergence through the data analysis plan. In the data analysis plan, I also outlined the link between the research questions, the TPACK conceptual framework, and the themes based on the data.

Tracking Data and Emerging Understanding

Participants' information will be kept confidential. I did not use the personal information of participants for any purposes outside of this research project. Also, I did not include their names or anything else to identify participants in the study report. Also, I will keep data on a password-protected hard drive connected to the computer while processing the data. The removable hard drive will be encrypted and kept in a locked vault at my house. Personally, identified viable information was only first and last name, phone number, and email address. This information will be kept in one form and locked away in a vault. I have only access to that information. A unique numbering system will be used to link recordings to the individual. When published in the results section of the project study, a pseudonym will be used for each person. I will also destroy participants' data after keeping it for five years.

Access to Participants

Access to Participants Prior to collecting data, I obtained IRB approval from Walden University. An IRB approval is needed to assure the participants' protection and establish an ethical project study. Once Walden university IRB approval was given, I emailed mathematics teachers inviting them to participate in the study. Once teachers volunteer to participate in the study, I organized an interview date and time for in-depth data collection.

Role of the Researcher

The researcher's role in this qualitative research was to access participants' thoughts and feelings (see Patton, 2015). I had no roles and responsibilities in the local setting, and I do not teach at the research site. I had no professional experiences or relationships with the participants, and I was unfamiliar with their research site experiences. DeVaney (2016) argued that good qualitative researchers remove emotion and focus on participants' characteristics and engagement. DeVaney explained the need to be constantly aware of feelings, opinions, and prejudice and be open to data and evidence that may not fit my current thoughts. I entered the researcher process to demonstrate a previously held position. My related basis to the TPACK conceptual framework used in the study is teachers' expectations. Hence, the expectation is for teachers to integrate e-learning in mathematics instructions and have content, technology, and pedagogical knowledge throughout the implementation process.

Data Analysis

In this section, I discussed the inductive data analysis approach. According to Saldaña (2018), inductive data analysis can analyze interview data from generating themes. I also summarized the findings and developed my interpretation in a narrative form. TPACK is the conceptual framework used in the study for which I explained how it is used to develop the a priori codes in the findings.

The inductive analysis involves coding the data without fitting it into a pre-existing coding frame or analytic preconceptions. This study adopted an inductive analysis to analyze the interview data in the spring term. I transcribed the participants' responses. I listened to the recordings for each participant and manually transcribed them for coding purposes. I re-listened each recording and ensured that I captured participants' responses. I also store recorded interviews on a flash drive, which I will keep in a fireproof locked vault for five years (see Saldaña, 2018).

I conducted data analysis using three steps. I developed and applied codes in step one and identified themes, patterns, and relationships in step two. Finally, I summarized the data in step three (see Miles & Huberman, 1994). I used open coding to make sense of the initial organization of raw data. I concentrated on conceptualization and categorization in the initial coding process. I did this through an intensive analysis of the data. According to Vollstedt and Rezat (2019), data is broken into smaller parts deeply analyzed initially. I compared the more minor analytical details concerning similarities and differences. Subsequently, I developed various codes to describe the data and refer to the TPACK conceptual framework domains.

In the second step of the data analysis process, I identified themes, patterns, and relationships from the data collected. I also employed two standard methods of qualitative data interpretation. The first method was the word and phrase repetitions. I scanned primary data for words and phrases most used by participants. This method helped me identify emerging themes, patterns, and relationships.

Additionally, I searched for missing information during the interview process. At the end of the interview, participants could share any other information relevant to the phenomenon not mentioned in the questions answered. I summarized the data in the third step of the data analysis process. At this stage, I linked my research findings to my research questions and the purpose. I endeavored to include vital quotations from the transcripts to highlight significant themes within my conclusions and contradictions.

I used a researcher’s journal to engage in memoing in which I recorded reflective notes about what I had learned from each participant’s data. I wrote memos to myself when prompted with new ideas and insights. This journal helped me triangulate, verify, and control bias during data analysis. I then analyzed these new ideas and insights. I relistened each recording to ensure that the resulting transcription included a complete and accurate summary of each interview. I made several stops to adjust and correct any errors in the word document. Also, I manually sorted and coded the data to analyze the transcribed data and develop an in-depth understanding of the participants' responses. Finally, I created relationships between words and phrases identified in the data set (see Saldaña, 2016).

Evidence of Quality and Procedures

To achieve trustworthiness, I discussed member checking, the researcher's journal thick description, and discrepant cases.

Member Checking

I used member checking to return the findings to the participants to review the findings for their data accuracy. To achieve this, I sent participants a two-page summary of the findings. Participants received my findings via email to verify and return within ten working days. Based on participants' responses sent via email, I made better sense of my findings.

Researcher's Journal

I used my journal to record my initial thoughts in each data collection session. According to Patton (2015), reflective journal commentaries could play a vital role in monitoring the researcher's interpretations in establishing credibility. Additionally, my recorded statements played a crucial role in monitoring my developing interpretations of the phenomenon.

Thick Description

I used a thick description to describe the research setting and findings. The goal was to thoroughly explain essential and contextual factors in the local setting (see Carl & Ravitch, 2016). A thick description is crucial for increasing my research's complexity through a thorough and precise description of the study's context, participants, and related experiences. Subsequently, a thick description allowed for complex interpretations and findings, enabling the reader to make a more contextualized meaning of the research. This study's thick description connotes a depth of contextual detail through interviews, transcript excerpts, or quotes (see Creswell & Creswell, 2018). Including transcript excerpts in my thick description could allow readers to participate in the validation of my findings. Additionally, Carl and Ravitch argued that the reader would have enough information and a depth of context to picture the setting and their perspectives on my research quality and interpretations. Similarly, Creswell and Creswell explained that qualitative study must convey detailed descriptions that provide an education for readers and a sense of realism.

Discrepant Cases

Another measure to ensure credibility is the analysis of discrepant cases. Discrepant cases are data found to be inconsistent with the emerging themes. Carl and Ravitch (2016) argued that researchers should not force data to confirm their preconceived notions but instead search for negative cases (discrepant cases) that do not fit the pattern or the current understanding of the data. Additionally, before I consider a data set to be discrepant, I need to know why the information is applied and what it means in the research context. In further discussion, Carl and Ravitch also encouraged researchers to look for discrepancies and pieces of evidence that challenge and complicate the research finding (2016).

Data Analysis Results

In this section, I outlined the results of the inductive data analysis. Four major themes emerged one subtheme emerged during the process. I also align the themes with the research questions and the conceptual framework included in the discussion of findings. I used the TPACK conceptual framework in the study. I then discuss the overview of the themes, categories, and codes. Also, I noted discrepant events and the use of member checking. Finally, I summarised the discussion by explaining mathematics teachers' perceptions and noted a blended professional development course in e-learning as a project to initiate.

I created a table (see Appendix H) that contained four primary themes and one subtheme linking to theme two. The emerged themes are:

- Theme 1. Benefits and problems with e-learning integration in mathematics.
- Theme 2. Teachers perceive their proficiency in e-learning implementation.
- Subtheme. E-learning tools teachers need to access for planning and mathematics instructions.
- Theme 3. Teachers experience barriers during e-learning integration.
- Theme 4. Professional Development is needed to support e-learning integration.

To summarise the inductive data analysis process, five underlining principles. First, I analyzed through multiple readings and interpretations of the raw data. Second, although my findings were influenced by the research questions and the TPACK theoretical framework, the themes arose directly from the raw data and not from prior expectations. Third, my findings resulted from multiple interpretations made from the raw data. To make my findings usable, I revisited the research questions and the TPACK model to determine what conclusions were related to essential categories and themes. Fourth, I reviewed my findings for redundancies and overlaps. Finally, I assessed quality evidence through member checking (see Appendix I) and shared two-page findings to each participant (see Creswell & Creswell, 2018).

Discussion of Findings

This section discussed the findings related to the two research questions (RQ 1 and RQ 2) and the alignment with the a priori codes, CK, PK, and TK. I described the emerging themes from the data and some discrepancies. During the inductive coding process, many categories emerged. I reviewed the categories identified during the coding process for similarities. I grouped them in the following themes: (a) teachers' perceptions and attitudes regarding the use of e-learning to teach mathematics, (b) teachers' perceived proficiency in implementing the e-learning in mathematics, (c) teachers identified e-learning tools included in planning and instructions (subtheme), (d) teachers' perceived barriers regarding the implementation of e-learning in mathematics, and (e) teachers' perceived support for implementing e-learning in mathematics.

RQ 1 captured teachers' perceptions of implementing e-learning in mathematics courses. This section explained participants' content knowledge alignment with RQ 1 and the associated themes that emerged. Data showed that participants used their content knowledge to select and use appropriate e-learning tools. GeoGebra, a mathematics software, is a frequent e-learning tool participants use to teach geometry. The data showed that teachers used this interactive graphing tool to explain graph-related content and the opportunity for students to practice problems independently. According to Participants 1, 2, and 3, GeoGebra is selected and used in mathematics lessons to minimize misconceptions and encourage concrete understanding. Based on the data, Participant 4 also used GeoGebra to demonstrate challenging concepts and to differentiate his classroom instructions during his geometry lesson. Based on my recorded memos, these participants have the content knowledge needed to use GeoGebra effectively in their mathematics courses. Although participants commonly used GeoGebra as an independent technology tool, Participant 1 added that she included instructional videos in her mathematics lessons to bolster students' retention. She explained that the video would provide additional guidance and repetition for students to engage in the concept. While noting the advantages of e-learning in mathematics, Participants 1, 2, and 3 were fully aware of shortcomings when integrating e-learning. They confirmed that "not all e-learning platforms are appropriate since they do not always allow students to visualize the concept." Although Participant 1 and participant 3 expressed being average with the implementation of e-learning, data showed that they both have high confidence and appropriate content knowledge to implement e-learning in mathematics. With the demand for e-learning increasing, these participants endeavor to learn more and do more by using technology.

Based on the data, CK for Participants 4, 5, and 6 is high. Both Participants 4 and 5 outlined how they created and used instructional videos in mathematics instructions. According to Participant 5, “students can revisit what was taught using instructional videos and that “if one class has a misconception, you can find other clips that explain more simply.” Similarly, Participant 6 mentioned using manipulatives to achieve his goal to move students from the concrete stage to an abstract stage of learning. Again, although it is time-consuming, Participant 6 also asserted that instructional videos provided a step-by-step guide to help students grasp challenging concepts specific to what task they are completing. He also mentioned that “you need to teach to the diverse learners, which confirmed Participant 4 assertion of teaching for diverse learners. Further to the discussion, Participant 4 and Participant 5 confirmed the importance of instructional videos to address diverse learning needs. These participants can easily select appropriate e-learning tools based on the foreseeable advantages while noting the limitations of teaching and learning.

Data showed the alignment of participants’ PK linked to the themes and RQs. According to one participant, she always tries the best way to use technology to “enhance the teaching and learning process” by using different e-learning platforms such as “Google forms, Google sheets, Google classroom.” The data showed that all participants used the Internet to research and deliver mathematics concepts and YouTube videos. Participants mentioned using GeoGebra, Schoology, Edmodo, and Microsoft Excel to consider diverse learning styles and improved learning outcomes. The data shows that participants said learning styles or needs twenty-two times regarding teaching and learning. One participant mentioned learning styles nine times, as seen in the data. The participant mentioned statements such as, “ensure that your delivery is relevant to all learning styles” and “you must check to see which tool facilitates learning based on students’ learning styles.”

Participants demonstrated their pedagogical knowledge by being a facilitator. The data showed that participants facilitated students working independently, allowing for discourse, peer communication, and research. One participant mentioned that “software allows students to work independently.” Another participant said, “they would view videos independently to help with their misconceptions.” Additionally, one participant mentioned that “faster students could teach their peers who are slower” to facilitate teaching and learning in their mathematics lessons.

Participants were optimistic about technology integration use but mentioned e-learning implementation, limited knowledge, and training as limiting factors. Based on the data, 100% of participants confirmed that they independently conducted research and practice with modern technology such as Google suite and free Internet tools for mathematics instructions. Participants also mentioned the use of Google Classroom to deliver lessons and self training with Google forms, Google sheets, and google classroom. Additionally, participants supported their lessons using instructional videos and content-specific mathematics software. Participants also outlined their confidence to use Google suite to monitor students' progress, provide feedback, and generate assessments.

Research question 2 focused on the support teachers perceived needed to implement e-learning in the classroom. Based on the data arising from this research question, theme 4 emerged, which uncovered the professional required for teachers to integrate e-learning. I will explain the relationship between RQ 2, the three main TPACK domains, and theme 4. Based on the data, participants' CK was evident among all participants. Participant 5 emphasized that effective communication among students and their parents or guardians could build on students' proficiency in mathematics. According to Participant 1, "communication is needed with students and parents." That communication would provide feedback and encourage discussion about content development and assessment outcomes using e-learning. Communication with parents would also establish consistent parental support for each student during the learning process. The data also showed that Participant 3 confirmed the need for continuous dialogue with learners. According to Participant 4, communication with students would help the teacher chunk the content to achieve high mathematics proficiencies.

The qualitative data showed that all participants needed to develop their TK to access reliable technological tools and infrastructure to implement e-learning effectively. Participants were aware of the TK support to integrate e-learning, and the support needed varied to include a mix of internal and external support. Participants mentioned "mathematics software," "reliable Internet and electricity," "e-learning materials," and "access to Internet service" as vital support required. The mentioned assertions represented 80% of participants. The data also showed that all participants yearned for greater frequency in ICT or e-learning training specific to mathematics instructions. Support in these areas would help participants plan and secure appropriate e-learning tools for classroom instructions. Based on the data, addressing these technological issues would enable teachers to implement e-learning seamlessly.

The data showed that professional development (PD) is needed to boost teachers' PK in e-learning implementation. 80 % of participants said PD is required, and the next 20% mentioned the need for collaboration among teachers to share best practices. Based on the data, Participant 4 suggested "the need for e-learning training," Participant 5 outlined that "more e-learning training is needed," and Participant 6 referred to the need for teacher-specific training. The assertions of these participants aligned with the TK support they mentioned regarding PD. The data also showed that Participant 3 and Participant 5 needed active engagement among teachers to develop their pedagogy in e-learning implementation. Finally, a classroom upgrade was established in the data to encourage e-learning implementation.

Overview of Themes, Categories, and Codes

I analyzed data from the interviews to identify emerging themes and then summarized them in four tables. The tables display my findings which support the final analysis. The table includes three columns: themes, categories, and codes. Four themes emerged and one subtheme. Table 3, Table 4, Table 5, and Table 6 broke out the themes into *teachers' perceptions and attitudes regarding the use of e-learning to teach mathematics, teachers' perceived proficiency in implementing e-learning in mathematics,* *teachers' perceived barriers regarding the implementation of e-learning in mathematics, and teachers' perceived support for implementing e-learning in mathematics. Subtheme identified is teachers identified e-learning tools included in planning and instructions.* The themes reflected the research questions, and the evidence depicts participants' quotes for each theme.

I used two rounds of coding for the interview responses that gave way to several topics from participants. Based on the participants' perceptions, there were several similarities and differences in their perceived experiences with e-learning. In vivo and priori coding led to axial coding, in which many categories emerged. I sorted the categories into four overarching themes (see Appendix H).

Theme 1: Benefits and Problems With E-learning Integration in Mathematics

The emergence of theme one directly aligned with interview questions related to the e-learning implementation process. I grouped the codes identified into the category, perceived alignment of e-learning to teachers' differentiated instructions. After the grouping process, I broke it down into two categories (see Table 3) to examine the perceived benefits or lack of help for teachers and students.

Table 3

Research Question 1 and the Emergence of Theme 1

Theme	Category	Code
Theme 1: Benefits and problems with e-learning integration in mathematics	Perceived alignment of e-learning to teachers' differentiated instructions • Perceived benefits/lack of benefits of e-learning integration for teachers • Perceived benefits/lack of usefulness of e-learning integration for students	Unreliable, access, problem-solving, inquiry-based learning, content development, students' achievement, enhance, track outcomes, engagement, independent learning, conceptual learning, more accessible, curiosity, retention, learning styles, responsible, communication skills, mathematics proficiency, confidence, cross-curricular advantages, interactions, participation, blended learning, address a misconception, instant feedback, personalize learning, facilities, organize data, immediate feedback, equity, inclusion, differentiation

The data showed that the benefits of e-learning usage in mathematics courses outweighed any negatives. Based on the data, the benefits to teachers include tracking students learning outcomes, developing differentiated instructions, organizing data, and inclusion. Three participants confirmed that e-learning enables them to track students' progress. According to Participant 1, "Google forms platform helps me track students' participation and task completion. This platform also provides an analysis of what students have produced. I would use this information to modify my technological-based assessments. I also use the online quiz and project-based assignments to do my assessment through e-learning."

Additionally, Participant 2 added, "Jesus, I love that thing online. I used quizzes online using google classroom to produce scores and an individualized analysis for each student who did the assessment. This online quiz can track students' progress in my mathematics lesson." Similarly, Participant 3 weighed in and outlined, "I used different technologies in the classroom, such as the Internet and YouTube videos. I would allow students to watch a related video explaining the concept. I would then provide related questions which students would answer. I would also research and note different teaching approaches that I could use to integrate the technology. After these lessons, I will assess students' understanding to check if they still have a misconception." Participants also confirmed the benefits of e-learning by using a learning management system (LMS). According to Participant 4 and Participant 5, the school adopts a website called Wrenweb, which allows teachers to manage students' mathematics progress and makes it less tedious to gather and analyze data. These participants also mentioned using. Finally, both participants confirmed that e-learning bolsters differentiated instructions in their mathematics lessons and Google forms to produce graphs to track students' applications and inform planning. Participant 6 argued that e-learning evokes interest among learners and that pedagogy now caters to diverse learners.

Notably, the general assertion by participants is that the e-learning lessons should cater to all students and that there are noticeable opportunities for greater inclusion among learners using e-learning. The data showed that the medium used is essential when implementing e-learning. According to several participants (Participant 1, Participant 2, Participant 4, Participant 5, Participant 6), different mediums aided students in understanding and retaining the concept. Participants also argued that technology added practicality to the lesson and helped students connect their big imaginations through e-learning. Accessibility to e-learning was one perceived lack of benefit to both teachers and students. The data showed that both teachers and students had problems accessing the e-learning tools, especially during the pandemic (Covid-19).

Several benefits emerged for students through the integration of e-learning in mathematics lessons. Based on the data, e-learning integration allowed students to develop critical thinking skills and become problem-solvers. Leaners also had the opportunity to be inquiry-based learners, be more engaged, improve their retention of tricky mathematical concepts, and raise their achievements in their summative assessment. According to one participant, “Mathematics is about problem-solving. Give students a scenario using technology for them to solve.” Another participant said, “I use a different medium, such as instructional videos and tutorials, for my instructions that aided their learning and retention of previous concepts taught. Regarding achievement, Participant 2 said, “I think the mathematics concept is sometimes abstract, and technology can bridge the gap that exists between the teaching of the concept and the desired learning outcomes.” In other words, “the technology adds the practicality to the lesson and helps students connect their big imagination through e-learning.”

The data showed that there were other benefits to students through e-learning integration. Other benefits to students include them becoming conceptual and independent learners. Participants mentioned that "I think students initially have a positive attitude to the use of e-learning in lessons through audio-visual means." A positive attitude results from students understanding the technology and the expectations of the given task. As a result, students became more engaged and developed continued positive attitudes. Participants also mentioned that "if students are more engaged in the lesson; it enhances the teachers' technological knowledge. They can now reflect on other appropriate e-learning tools in future lessons. Finally, the data showed that a positive attitude results from students overseeing their learning and acquiring the satisfaction and comfort of doing something independently."

Theme 2: Teachers Perceive Their Proficiency in E-learning Implementation

The emergence of theme 2 derived from participants' self-rating while planning with and using technological tools. I grouped these codes into two categories (see Table 4). These categories are (a) self-reported knowledge of e-learning integration and (b)implementing e-learning. Four participants reported that they were knowledgeable about Google suites and used them frequently. The other two participants were also familiar with Google Suite and Microsoft Excel during the implementation process. Participants rated their e-learning integration and implementation knowledge using numbers and words (See Appendix H, Theme 2). Participant 1 mentioned, "I am moderate with the use of e-learning, and I am still learning." Participant 2 added, "I try to keep myself current with new technological development and give myself 91%."

Table 4

Research Question 1 and the Emergence of Theme 2

	Category	Code
Theme 2: Teachers perceive their proficiency in e-learning implementation		Good, very good, developing, researching, self-taught, five, seven, nine, average, medium, not 100%, confident
Subtheme: E-learning tools teachers need to access for planning and mathematics instructions	- Teachers reported e-learning tools included for planning and instruction. - Teachers reported strategies included for planning and instructions Identification of e-learning tools teachers least/ frequently have for planning instructions Identification of strategies teachers least/often include for planning and instructions	Manipulating, diagnostic testing, analyze, classroom management, teacher forum, Quizy, google suite, Schoology, smartboard, Wrenweb, tablet computer, Ms. Excel

Participant 2 said, “I am at the moderate level. I am still researching technology integration.” At the same time, Participant 4 added that he is “more than average and had an exceptional knowledge of technology integration, and giving my knowledge is 8.5/10”. To this point, Participant 6 said he gives himself “7/10; more needed. There is always room for learning.” He also said that he is “competent in using e-learning in the classroom.” Finally, Participant 5 mentioned that “I learn by doing,” “I teach myself, and I find it easy.”

One subtheme emerged within theme two, which reflected e-learning tools included by teachers during planning and instructions. The two categories included e-learning tools used in planning and strategies included for planning and pedagogy. The data showed that participants plan for students based on their learning needs and available e-learning tools. Participants mentioned using Google suites and associate applications to prepare and deliver instructions online. Teachers sometimes use Smartboards and MS Excel to plan and deliver the lesson. Participants also mentioned collaborating with teachers to share best practices (see Appendix H, subtheme).

Theme 3: Teachers Experience Barriers During E-learning Integration

Theme 3 emerged from the data, showing that participants identified e-learning integration barriers. I separated the barriers into categories named these categories as (1). Teachers and (2). Students. Two subcategories focused on issues in and outside the classroom that affected e-learning implementation (see Table 5). Codes formed included preparation, collaboration, support, instructional strategies, diverse learners, and professional development (PD). Other codes are changing technology, expertise, Covid-19, and reliability of e-learning tools.

Table 5

Research Question 1 and the Emergence of Theme 3

Theme	Category	Code
Theme 3: Teachers experience barriers during e-learning integration	Self-reported barriers to e-learning implementation for students Self-reported barriers to e-learning implementation for teachers • Identification of issues inside the classroom that affect e-learning implementation • Identification of issues outside the classroom that affect e-learning implementation	Preparation, collaboration, support, instructional strategies, diverse learners, personal development, and professional development (PD), changing technology, access, unreliable, unavailable, expertise, infrastructure, Covid-19

The data showed that teachers had to work from home during the covid pandemic. Due to the pandemic, teachers would need to use their current knowledge of e-learning and technological devices' limits to plan and deliver lessons for students via the Internet. It also meant that students would need to access their classes online synchronously and asynchronously. Two participants mentioned using instructional videos but lamented that it is only usable but depends on the reliability of the Internet of electricity to themselves and the students. Additionally, participants mentioned that "resources are lacking" and directly affect the teaching and learning process.

The data also showed that the lesson must address all learning styles needs, but not all software help explain specific topics appropriate for diverse learners. Moreover, one participant asserted that “some of the tools you would want are not readily available” since other teachers need to use them simultaneously, which can become chaotic. Also, the “classroom is sometimes not conducive for e-learning implementation.” This situation may lead to students losing interest in the lesson. Participants also mentioned a lack in the frequency of PD training in e-learning. 100% of participants asserted that more training is needed. Since PD training is lacking, one participant said, “I depend more on other mathematics teachers than getting formal PD.” At the same time, another participant pointed directly to a lack of government assistance (see Appendix H, Theme 3).

Theme 4: Teachers’ Perceived Support for Implementing E-learning in Mathematics

Theme 4 emerged from two main categories and two subcategories. These categories are: Perceived online and face-to-face PD for teachers to implement e-learning (see Table 6). The codes related to this theme are ICT, Internet, PD workshops, teacher forum, software, and infrastructure.

Table 6

Research Question 2 and the Emergence of Theme 4

Theme	Category	Code
Theme 4: Professional development is needed to support e-learning integration	- Perceived online PD for teachers to implement e-learning - Perceived face-to-face PD for teachers to implement e-learning • Identification of medium for online PD for e-learning implementation • Identification of medium for face-to-face PD for e-learning implementation	Information communication technology (ICT), Internet, PD, workshop, teacher forum, collaboration, communication with parents, computers, software, infrastructure, experts, college training, national training (JTC), frequent training

Participants mentioned the need for more face-to-face expert professional development based on the data. Professional development can be a teacher forum or focus group using different mathematics software on a computer as a department. This department training can help teachers use the Internet to download and trial mathematics software that they can use in their mathematics courses. Participants also mentioned online training. According to Participant 6, “parents can also be a part of e-learning training." Online training can include national training through the Jamaica Teaching Council (JTC) for teachers (see Table 6).

The data has shown that e-learning training must be frequent to keep teachers current in the classroom. Participants mentioned that they needed "more ICT training in technology integration and exposure" and "ICT workshops in the district and region," aligning with a national training program. The data have shown that the classroom needed adequate equipment with the necessary hardware for e-learning implementation. One Participant 1sserted that "the classroom needs upgrading." Consequently, the data showed that 100% of participants confirmed the need for continuous training with ICT for seamless e-learning implementation in mathematics.

Researcher's Journal

In this study, I used a researcher's journal to code, categorize, and theme participants' responses during the interview process. I also note the tone and general attitude of participants. I also used memos from the journal for triangulation, verification of content, and managing my bias. I used the journal entries as evidence to gain an insight into the experiences of each teacher during their mathematics lesson as they implement e-learning. My reflective journal captured the teacher's attitude and perceptions during the interview process and the emergence of CK, PK, and TK while implementing e-learning in mathematics lessons. During data collection, teachers' perceptions were responsive to the research questions; what are secondary mathematics teachers' perceptions on the implementation of e-learning to teach mathematics? And what support do teachers perceive is needed for secondary mathematics teachers to implement e-learning in the classroom?

Discrepant Findings

There are four discrepant findings related to research question one (see Appendix H). The findings showed similarities among five participants who answered interview questions related to the research question. However, the first discrepant finding was a response to interview question one. According to Participant 2, “the resources are lacking” when asked about the usefulness of e-learning in mathematics. This response suggests the need for e-learning resources for implementation to be practical. All other participants gave a specific answer to this question. Assertions by other participants included statements like, “technology will help to enhance the retention,” “Is vital importance,” and “e-learning allows for differentiated instructions.” For the same question, another participant said, “they can revisit content taught using technology,” Finally, the sixth participant said, “using e-learning enhances the lessons and student engagement.”

Another noticeable discrepant finding was the experience level among the participants’ use of e-learning in mathematics instructions. The data showed that 20% of participants were the least experienced and categorized themselves as “moderate” and “average” when asked about their e-learning knowledge in mathematics instructions. For the same question, the remaining 80% of participants rated themselves using phrases such as “seven out ten,” “Very good,” “I find it easy,” and “I am giving myself 91%”.

Participants representing 20% also added that "I got some training recently" and "I am still doing research."

Additionally, the third discrepant finding related to two of the six participants' interest levels when preparing for e-learning implementation. The data showed how flexible these participants were during the execution of e-learning. One participant said, "I would create different documents in excel to allow students to do automatically generated calculations." Also, the second participant mentioned that "I used Microsoft Excel to create interactive worksheets." Both participants engage in long planning times for their lessons.

I identified a fourth discrepant finding related to research question one. The data showed that all participants agreed that e-learning integration is beneficial. The data showed that 100% of participants said e-learning improves students' interaction and engagement. 20 % of the participants emphasized that e-learning aids students' retention. The data also showed that 100 % of participants believed that e-learning helped solve problems and clear misconceptions when used synchronously or asynchronously.

Finally, I identified one discrepant finding related to research question two. Although participants used varying descriptors and phrases, the data showed the same meaning. When asked about the support needed to implement e-learning, the data showed that 100% of participants referred to the availability of e-learning tools inside and outside the classroom. Participants mentioned the need for communication with parents, more resources, and frequent technology training. 100% of the participant said the frequency of PD is low. Consequently, the data showed that barriers faced by teachers implementing e-learning are linked to support needed to implement e-learning inside and outside the classroom (see Appendix H).

Evidence of Quality

Ethical Procedures

The procedures involve in ethical procedures are vital for the research process. I received approval from Walden University Institutional Review Board (IRB) for permission to conduct my study, having met the protocol related to ethical procedures. During the university research review (URR) process, I submitted an online application for IRB guidance towards achieving the research protocol required to start my data collection. It is important to note that I copied each time I emailed the IRB in my chair. The IRB also copied my chair when responding. Having completed the initial IRB electronic document, they wrote back outlining the documentation needed for the second stage. After receiving the URR approval via my electronic portfolio Taskstream, I sent the required documents to the university IRB. These documents included a cooperation letter from the partner organization, an invitation letter, the consent form, and the collaborative institutional training initiative (CITI) certification. I also submitted the interview protocol, the selection letter, and a Form C ethics document. The IRB edited the ethics document several times before giving permission for the study to proceed.

Through the CITI program, Walden University required me to complete six courses with a minimum score of 60 out of a possible 88. I mastered and completed all six courses in December 2020. These courses included, History of Ethical Principles, Assessing Risk, and Informed Consent. I finished the remaining courses, Privacy and

Confidentiality, Unanticipated Problems and Reporting Requirements in Social and Behavioral Research, and the Belmont Report.

The protocol of my study allowed participants to withdraw at any time without prejudice or consequence. If a participant wishes not to continue with the process, their information remains confidential. Before initiating the data collection, I emailed potential participants an invitation letter. Selected participants received a selection letter and a consent form via email. Participants had to reply by saying ‘I consent’ before organizing dates and times for interviews to initiate. The consent form explained the procedure for data collection and the projected duration for the interview.

Member Checking

I used member checks to rule out incorrect interpretations of participants’ opinions while sharing their perceptions. Member checking in my study contributes to my research’s dependability and stability. During this process, I sought confirmability. I used Birt et al. (2016) member checking questions for interview transcript, analysis codes, and findings table (see Appendix K) to guide the member checking process in this study. According to Carl and Ravitch, establishing confirmability mitigates researcher bias. An objective of confirmability is to acknowledge and explore how researchers use the data to interpret their personal preferences and prejudices. The researchers would use objective reflective practices to address the preferences and prejudices. The researcher must analyze the perceptions of participants in an unbiased way to reflect what the data is saying. I transcribed the data using Microsoft Office365 dictate, then relistened the recordings to ensure that the transcribed data mirrored what each participant said. I manually coded the data to identify salient points emerging from participants' perceptions and intent to achieve deep understanding.

I used a researcher's journal to memo my participants' perceptions of implementing e-learning in mathematics lessons to triangulate my findings throughout the interview and the data analysis process (see Rubin & Rubin, 2012). Guided by the arguments of (Carl & Ravitch, 2016; Merriam & Tisdell, 2016) on reflexivity, I can confirm that the research questions were answered through reliable data. The research process, known as reflexivity, affects and is affected by the researcher. Also, reflexivity is the process by which researchers question themselves with a series of questions regarding their actions and how they affected the data and the research findings. Subsequently, the use of a reflexive process led to an effective and impartial analysis (see Carl & Ravitch, 2016).

Summary

I designed a basic qualitative research study to address an urban secondary school in Jamaica regarding mathematics teachers implementing e-learning in the classroom. The purpose was to explore secondary mathematics teachers' perceptions on the implementation of e-learning to teach mathematics and their support to implement e-learning. I conducted semi-structured interviews with teachers closely associated with the problem to understand this problem. After data analysis, four themes emerged, one subtheme, and evidence for those themes in section 2. Although teachers showed CK, PK, and TK, there is a need for continuous PD training to develop new experiences among teachers.

Research Question 1

The first research question explored teachers implementing e-learning to teach mathematics. Three themes and one subtheme that emerged from the data align with the research question. The themes captured teachers' perceptions and attitudes, proficiency, and barriers to implementing e-learning. According to teachers, amidst the barriers to the implementation process, the benefits of e-learning integration are significant, as shown in the data. In general, teachers are optimistic about e-learning, although not all are experts. Teachers who could network with other teachers, plan, and research extensively were more confident implementing e-learning.

On the other hand, with the scarcity of technological tools and formal training, some teachers could not implement e-learning effectively based on students learning needs. More able teachers would familiarize themselves with innovations but use a blended approach in their classroom. These teachers' experiences become more beneficial when they include direct learning experiences for their learners and are more likely to adopt new pedagogical practices over time (see Rapanta et al., 2020).

Research Question 2

The second question aimed to understand teachers' support for e-learning in their mathematics courses. One theme emerged for this research question: response to perceived support for teachers' needs. According to teachers, they require online and face-to-face continuous PD training to implement e-learning. Teachers found PD training to be the main barrier and mentioned the unavailability of technological tools and the need for classroom infrastructure. The teachers in this study engaged themselves with e-learning implementation, with some seeking formal training, self-taught, and engaging in research. According to Prott (2019), teachers need continuous PD training, which facilitates skill development required to respond to the 21st-century classroom. Teachers need new technological software and hardware relevant to the mathematics content and students' learning needs.

TPACK in Mathematics

The three main domains of TPACK were evident among teachers at varying levels in this study. The main domains are content knowledge (CK), technological knowledge (TK), and pedagogical knowledge (PK). All participants had the relevant content knowledge to deliver their mathematics lessons. The challenge was the technological knowledge needed by some teachers to implement e-learning effectively. While all teachers had some level of training, their technological knowledge was not at the same level. Two participants had limited technological knowledge and expectations and needed to deliver a lesson.

Additionally, while teachers remain flexible and welcome novel changes, minimal technology knowledge could affect their pedagogical knowledge. Although teachers could use Google Suite effectively, more mathematics-specific software could pose a challenge without expertise training. In general, teachers had the necessary content, technological, and pedagogical knowledge to implement e-learning given the current situation with Covid-19 and the available resources. According to Lee et al. (2020), technology integration can help students construct new knowledge, explore innovative ideas, be self-directed, and develop collaborative skills.

Project Deliverable

Implementing a blended professional development course for teachers may increase their motivation, confidence, and commitment to teaching. The project deliverable was a three-day blended professional development course that educators could use across secondary schools to stimulate teachers' professional practices and develop students' mathematics proficiencies. A blended professional development could allow teachers to learn and collaborate with other teachers. Teachers could use the new skills and strategies acquired to influence classroom practice and encourage learning in the classroom.

I analyzed the results of this study to determine how best to solve the identified problem of how secondary mathematics teachers in an urban secondary school implement mathematics e-learning in the classroom. The analysis of the interview data emerged four themes: *teachers' perceptions and attitudes regarding the use of e-learning to teach mathematics, teachers' perceived proficiency in implementing e-learning in mathematics, teachers' perceived barriers regarding the implementation of e-learning in mathematics, and teachers' perceived support for implementing e-learning in mathematics. Subtheme identified is teachers identified e-learning tools included in planning and instructions.* The project deliverable is a three-day blended professional development course appropriate to improve teachers' ability to implement e-learning in their mathematics courses and encourage best practices in their professional practices.

The deliverable portion of this project is a three-day blended professional development, split into two sessions per day that cater to teachers' need for blended learning experiences. Teachers will get the opportunity to practice implementing e-learning through peer collaboration, communication, and planning using content-specific e-learning mathematical programs. The three-day blended professional development course training is specific and would benefit both teachers and students. They would develop the necessary content and technological knowledge to use the tool effectively. The teacher could also help if they adopted their planning and instructions to include technology.

The professional development course for this project aimed to tackle teachers' confidence in using new e-learning tools in the classroom. Therefore, the materials will focus on pedagogical, technological, and content knowledge specific to urban secondary schools. Although the professional development would not fix the lack of e-learning hardware, the expectation is that teachers would welcome professional development tailored to their needs. I expect teachers to play an active role in the learning process and take away what they perceive relevant to their professional practice. This professional development course may be challenging for several reasons. Still, teachers can gain and share new knowledge from a blended approach and use it in their classroom instructions. This professional development could alleviate teachers not being trained to use current e-learning tools in mathematics.

In general, the blended professional development deliverable designed for this study plans to acknowledge the benefits of developing the content, pedagogical, and technology knowledge of content-specific mathematics e-learning tools in teachers. Teachers will have the opportunity to access the professional development course online and face-to-face during the times allotted for professional development. Additionally, there is also an opportunity for parents to collaborate with teachers, thus building effective communication practices. Teachers would appreciate e-learning in mathematics and evoke lifelong learning in the school understudy.

Section 3: The Project

The project is a 3-day blended professional development course based on the needs identified in the data analysis. I gathered relevant notes and produced a PowerPoint presentation with appropriate technological information for teachers that aids e-learning integration. Although the presentation is specific to integrating e-learning in mathematics to develop students' mathematics proficiency, the skills gained are easily transferable to other subject disciplines. Students could also develop critical thinking skills and become self-directed learners.

In Section 3, I describe the project, and the goal for the professional development, the rationale for the plan, implications for social change, and the evaluation used to measure the project's effectiveness. Further, I include a literature review that guided the project's development. I considered the confines of the current literature on professional learning opportunities, e-learning integration in mathematics, collaboration and coplanning, and a growth mindset. I also include an implementation timeline for the project, a schedule, potential resources and barriers, existing supports, and the roles and responsibilities associated with the project. Appendix A contains the project deliverables.

Project Description and Goals

The purpose of this 3-day blended professional development course is to provide mathematics teachers with the opportunity to be involved in a collaborative e-learning community and coplanning techniques, including differentiated technology-focused topics to meet the needs of teachers. The program will help teachers develop required CK, TK, and PK to implement content-specific mathematics e-learning tools in their classrooms. The plan intends to advise the benefits of coplanning, coteaching, and collaboration among mathematics practitioners to develop expert knowledge of e-learning integration. The workshop will describe the benefits of coplanning and cooperation among teachers and positively influence teachers' daily interactions. Additionally, teachers may develop the skills to plan and execute technology-based lessons to develop students' mathematics proficiencies.

The planning for this project began by developing improvement goals and students' learning outcomes. I generated the goals and objectives from data analysis for the school under study. I used the teachers as the target audience of this professional development program because I collected and analyzed data provided by these mathematics teachers. The goals of the project are as follows:

1. Provide differentiated professional development to all teachers who use or want to use e-learning in their classroom and have no e-learning training that meets their individual needs. All participants mentioned a lack of professional development targeting their specific needs; this project will address those interviewees' concerns.
2. To encourage coteaching, coplanning, and collaboration among secondary teachers to promote mathematics and technology integration skills.
3. To promote the development of TPACK among teachers that reduces limits to technology integration in their mathematics courses. A positive professional development outcome would be for participants to see an increase in self-efficacy at the close of the school year.

4. To demonstrate that teachers can use e-learning to enhance secondary students' mathematics proficiencies. The literature indicated a high frequency of technology integration in mathematics compared to other subject areas, so this goal is to confirm the knowledge base on this topic.

Rationale

The logical choice for this study was a 3-day blended professional development course resulting from the frequency of teachers' responses to the lack of professional development for e-learning integration training. The research questions were designed to understand teachers' perspectives of e-learning use in their mathematics courses. During the data analysis process, it became apparent that teachers used the professional development offered in preparation for distance learning and online tools to keep current. However, teachers reported deficiencies in self-efficacy and new differentiated teaching and learning experiences using a virtual classroom and unfamiliar e-learning tools. At least two teachers expressed discomfort using a virtual classroom to impart knowledge over a prolonged period.

The literature review demonstrated that the study's findings set out the framework for designing a professional development course that meets the needs of teachers using e-learning in their lessons. The review of the finding's literature showed the need to overcome barriers such as lack of collaboration and planning as a group and to share best technology practices relevant to teachers' needs. The findings indicated that teachers would benefit from internal and external technology support to enhance teachers' self-efficacy and technological growth over time. The suggested blended professional development course will run over three days to allow teachers to develop and implement technology integration strategies they learned and provide ongoing training.

The emphasis of this blended professional development course was practical and meaningful communication, relationship building between mathematics instructions and technology integration, and building teachers' self-efficacy to choose the most appropriate technology strategies to integrate with their mathematics courses. Timing for this professional development could pose a problem, so considerations were made to avoid barriers to planning and collaboration by allotting timing suitable for teachers to interact, plan, and reflect on their practices. During the collaboration process, teachers can collaborate with like-minded individuals to increase the support among participants in the local setting.

Review of the Literature

Teachers must access high-quality professional development to meet students' needs and teach rigorous mathematics. A professional development course that allows teachers to work online can provide access to a broader range of teachers than face-to-face courses and can support teachers' self-efficacy. According to Bandura (1977), the social environment determines the behavior of individuals and the result of mutual interactions of personal factors. High self-efficacy relates to a higher TPACK. According to Yerdelen-Damar et al. (2017), fostering self-efficacy correlates with teachers' TPACK. TPACK served as a primary framework for blended professional development that bolsters teachers' TK, PK, and CK to improve students' learning needs (see Bakar et al., 2020). Further, Young et al. (2019) posited that technology-based professional development could effectively increase TPACK for mathematics teachers.

The TPACK conceptual framework was appropriate for this blended professional development course because it contains two guiding principles that guided the current research and the literature review. Although the TPACK conceptual framework was most appropriate, Holmberg's (2017) conversational framework would complement the TPACK conceptual framework in designing the blended professional development course based on its pedagogical and technological tenets. The TPACK connects to professional development to improve teachers' technology integration skills. Second, it improves teachers' knowledge, performance, and confidence in using technology. Akturk and Ozturk (2019) also argued that although students' social and emotional self-efficacy increases their academic achievements, the teacher's TPACK level significantly impacts students' learning.

Research for this literature review was collected using the Education Source database offered through the Walden University Library. I used several search terms, which include but not limited to *self-efficacy, teacher collaboration, personalized learning*, *teacher collaboration*, *professional development*, *professional learning*, *sustainable professional development*, *blended professional development, course design*, *course implementation*, *experimental learning*, *course evaluation*, and various combination of the above terms. I filtered the search results to generate peer-reviewed articles up to 5 years old.

Importance of a Blended Professional Development

Teachers' professional development affects society's development. There are e-learning needs among teachers in the classroom, which justified a 3-day blended professional development course while considering the TPACK theoretical framework. Implementing a blended professional development course may support professional skills and knowledge development. The course may promote teachers' adaptation to changing technology and learning opportunities to increase teachers' effectiveness and skill development (see Kristanto et al., 2017).

There has been an increased use of e-learning tools, and many institutions are using e-learning to communicate with students via distance learning in the educational field. According to Kristanto et al. (2017), it is vital to assess the feasibility and effectiveness of the development of e-learning instructional materials in the classroom. With the rollout of the e-learning project in Jamaica over a decade ago and the current pandemic, the need for a blended professional development experience is acute. Teachers need continuous training in basic learning management systems, content-specific applications, and websites to bolster their self-efficacy to implement e-learning in the classroom and move to a higher level (Fenton, 2017). Additionally, the premise of professional development must align with individual teacher needs and the growth of new and available technology.

Although Trust et al. (2016) argued that professional development should be long-term, constructive, and situated in the classroom practice, Darling-Hammond and Hyler (2020) outlined seven characteristics for effective professional development. Darling-

Hammond and Hyler also posited that effective professional development must be content focused, incorporate active learning, support collaboration, use models and modeling best practices, and provide coaching and support. Effective professional development must also offer feedback and reflection, which occurs over a sustained period (see Hill et al., 2017).

First, a blended professional development course that is intense and sustainable enables teachers to learn over time, practice their skills, and implement and reflect on new strategies that encourage changes in their practices. Additionally, this professional development must be coherent and support teachers across the professional continuum. Darling-Hammond and Hyler (2020) argued that professional learning should link to teachers' experiences during preparation and include teaching standards and evaluation. Professional learning should also bridge leadership opportunities for ensuring transparency for the growth and development of teachers.

Second, a blended professional development course that is content focused could increase students' mathematics proficiencies. Darling-Hammond and Hyler (2020) also posited that this professional development allows teachers to study students' work test new curricula with students focusing on pedagogy and student learning in the content area. Additionally, Darling-Hammond and Hyler posited that a blended professional development course could lead students to have higher learning gains than students whose teachers received content training only. Higher learning gains among students would occur because of teachers' increased CK and PK. Professional learning through this blended professional development that is context specific, job embedded, and content based is vital for addressing diverse needs among teachers and students in different settings.

Third, a blended professional development course that encourages active learning addresses how and what teachers learn. Darling-Hammond and Hyler (2020) explained that adults come to learn new experiences that should be utilized and reconstructed to generate new learning. Also, the adult must choose their learning opportunities based on interest and their own classroom experiences or needs. In addition, reflection and inquiry should be central to adults' learning and development. Active learning for these teacher participants would enable them to move away from traditional learning models that are generic, and lecture based. Instead, these teacher participants would engage directly in the learning practices connected to their classrooms and students. Fourth, the increased structured teaching in schools as a collaborative community endeavor requires teacher participants' collaboration during the blended professional development training. Teacher collaboration in the professional development course provides a basis for inquiry and reflection into teachers' practices, allowing them to take a risk, solve problems, and address dilemmas in their practice.

Fifth, models and modeling promote teacher learning and support students' achievement. This blended professional development course would include written teaching cases, demonstration lessons, lesson plans, peer observation, sample assessments, and student work. Professional learning that fosters the modeling of curriculum and classroom materials increases students' achievement compared to the noninclusion of modeling (Darling-Hammond & Hyler, 2020). Sixth, coaching and support effectively implement new curricula, tools, and approaches in education. Teacher participants would be at an advantage when they receive guidance and support during their professional learning training. As part of the coaching and mentoring, feedback and reflection are essential components of adult learning theory and these teacher participants' ability to modify their practices.

Feedback and reflection are the seventh vital component of effective professional development. This component often includes opportunities for teachers to share positive and constructive reactions to authentic instances in which teachers model their practices. These practices include lesson planning and demonstration lessons in a blended learning setting. Designing a blended professional development that incorporates the seven characteristics encourages problem-based learning and fosters teachers' effectiveness, collaboration, and self-efficacy. In addition to the TPACK conceptual framework, subsequent discussion of the blended professional development course design will include the conversational framework.

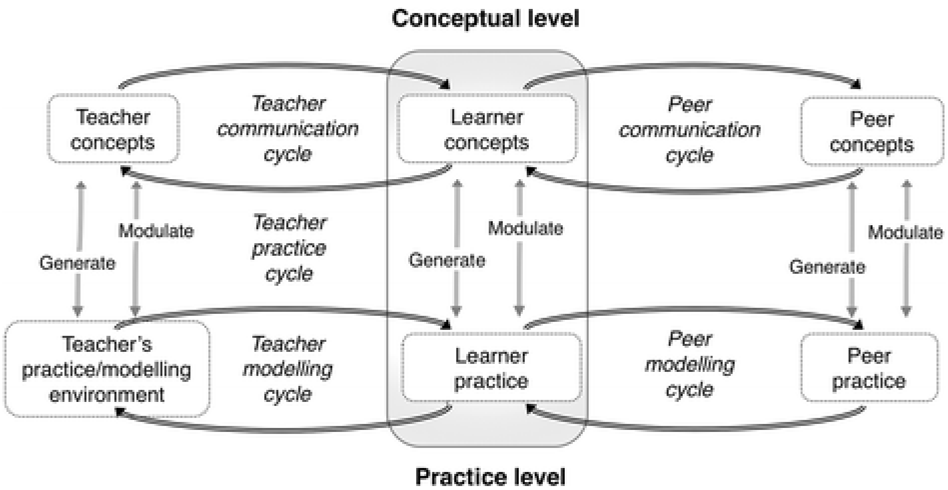
Blended Professional Development Course Design

The sustained growth of technology integration in classrooms for teaching and learning significantly affects the design of professional development (professional learning) courses for mathematics teachers. A blended professional development course is affected by technology integration and refers to learning taking place both traditionally and online. The general aim of blended professional development is to maintain harmony between conventional and online-based teachers (Suryanti & Arifani, 2021). The fundamental benefit of designing a blended professional development course is facilitating blended practices for mathematics teachers through meaningful interactions.

Current literature on blended professional development includes several studies that provide solid foundational support for course design. These studies (Boelens et al., 2015; Mirriahi et al., 2015; Wang et al., 2015) include innovative thinking that involves pedagogical and technological concerns in a blended learning and theoretical conceptualizations of blended professional development. In the subsequent discussion, the main principles of the conversational framework are outlined regarding its pedagogical impact. The conversational framework (Figure 1) is both a learning theory and a practical framework for designing high education environments that incorporate four dimensions of teaching and learning. These four dimensions include (a). teacher-students discussions, (b). adaptation of the learners' actions and the teacher's constructed environment. Also, (c) the interactions between the learner and the environment defined by the teacher, and (d) reflection of the learners' performance by both the teacher and learner (see Holmberg, 2017). The project deliverable three-day blended professional development course is based on the TPACK, and the conversational framework promotes self-efficacy and collaboration when teachers use technology. Accordingly, Holmberg posited that designing a course based on the tenets of the conversational model encourages scaffolded collaboration, working online independently, collaborating with a mentor, and then in small problem-based groups. The learning experience better prepares teachers for self-directed online tasks and collaborative activities conducive to reflective practices during group interactions.

Figure 1

Conservational Framework



Note. Adapted from "Applying a conceptual design framework to study teachers' use of educational technology," by J. Holmberg, 2017, *Education and Information Technologies*, *22*(5), 2333–2349. https://doi.org/10.1007/s10639-016-9536-3. Springer Nature. Open access.

In further discussions, Suryanti and Arifani (2021) argued that blended professional development courses in mathematics enhance teachers' creativity and effectiveness to use appropriate pedagogy that improves students' confidence, mathematics proficiency, and the acquisition of new knowledge. Brodie and Chimhande (2020) argued that a blended professional development course improves teachers' collaboration. The subsequent discussion explains self-efficacy through teacher creativity, effectiveness, and collaboration.

Creativity and Effectiveness

Teacher creativity and effectiveness affect students learning outcomes, thus positively correlated to learning achievement among learners. Teacher developing the skill of creativeness enhances their confidence, teaching styles, and the ability to overcome their barriers in the classroom. According to Suryanti and Arifani (2021), the blended professional development course must facilitate teachers in designing innovative lesson plans, peer teaching practices, case studies, solving mathematics problems, and best practice sharing to boost their confidence. According to Bonghanoy et al. (2019), best practice sharing is transformative learning that is observable when teachers become empowered, authorized, creative, and resourceful when their learning is transformative.

Furthermore, Suryanti and Arifani (2021) argued that blended professional development facilitates learners' opportunities for practice and cognitive aspects. Fuller (2021) also confirmed that blended professional development courses enable creativeness and effectiveness among mathematics teachers. Teachers who experience the e-learning environment could develop a new way of thinking about mathematics and of professional development they receive. Also, using GeoGebra mathematical software as an example emphasizes how teachers can engage in rich mathematical discussions to improve their confidence (self-efficacy) and eventually accept this e-learning mathematics software as a learning tool (see Fuller, 2021). Finally, teachers would then have an opportunity to use this software more effectively in the classroom.

Collaboration Among Mathematics Teachers

Collaboration among in-service mathematics teachers is essential to build opportunities for professional learning. According to Brodie and Chimhande (2020), teachers can discuss their mathematics knowledge and practice, the learner, and the learner thought processes during the implementation of a professional development course. Professional learning for teacher participants will encourage teachers to share their peer review practices and construct new knowledge and strategies suited for their classroom instructions. The output of the professional development should promote a change in culture, beliefs, and attitudes among teachers that their learners could emulate (Brodie & Chimhande, 2020). Collaboration among other teachers during a professional learning community is essential, but the inclusion of the school's administration in the collaborative efforts is motivating. According to Karacabey (2020), as part of teachers' professional development, the principal could support in several ways but not limited to guiding teachers to sign up for innovations in education and training, discuss teachers' strengths and weaknesses, allowing teachers to share newly acquired knowledge, and outsourcing assistance from local experts for professional development. Active involvement and collaboration with the principal could motivate teachers and build their self-efficacy (see Karacabey, 2020).

According to Little (2020), the opportunity for teachers to collaborate during a professional development course improves the teachers' self-efficacy. During the blended professional development course, teachers would have the chance to investigate the curriculum, instructional practices, and strategies. The teacher also has access to ideas, materials, strategies, and talent of the entire team, including other mathematicians and curriculum specialists. Additionally, peer collaboration, social interaction, and idea-sharing would prompt teachers to use new e-learning tools in their lessons (Fuller, 2021).

Conclusion

Designing and executing a professional development course that provides the opportunity to develop self-efficacy, overcome limits to e-learning implementation, collaboration, and the introduction of web-based platforms is a challenging venture. Nevertheless, teachers need access to technological resources, expert support, and ongoing e-learning training and development. There are numerous benefits to teachers and students when educators embrace professional development in education. Teachers will have the opportunity to share their practices in a collaborative learning community and adopt reflective practices that enable them to develop the best practices needed to integrate e-learning to bolster students' mathematics proficiency. As a result, teachers will have increased their self-efficacy and levels of TPACK while developing their technological knowledge. A well-designed professional development that caters to teacher participants' individual needs is possible based on the criteria for effective professional development discussed in the above literature.

Project Description

Resource and Support

The teacher will implement the three-day professional development using appropriate resources. The schedules and activity directions in (Appendix J) will provide the presenter's guidance before the training commences. A laptop computer (including power adapter and hardware and software to access a smartboard is required for presentations, tracking activities, and continuous with participants. Participants will also receive printed handouts of self-assessment inventories (see Appendix J) to include other tasks included in the training. Electronic versions of all printed materials will also be available to all participants. The resources are made available within the school, and the presenter does not need to outsource or produce additional materials. The support expected from the school understudy is to release teachers for training during the training tenure, provide technology hardware and software for training, and ICT support where applicable.

Barriers to Implementing the Professional Development Course

There are barriers to implementing a professional development course in a school setting. The main barrier identified for this three-day blended professional development course is the possible conflict with teachers' administration training days. According to Taopan (2020), barriers can further span teachers' ICT literacy, internet connection, time constraints, and lack of ideas to create meaningful technology tasks. Also, the selected topic in the professional development program may not relate to an immediate learning need of an educator. Through the local ministry of education (MOE) guidance, the school administration allowed specific days during an academic year for professional development activities. As a result, the school decided how to administer professional learning for staff and the themes or topics they would cover. The apparent obstacle associated with implementation is not knowing how the administration at the school understudy will choose to schedule professional development training due to the ongoing pandemic. Taopan also argued that it is possible that immediate training will take precedence over this professional development program and potentially affect the overall schedule or sessions.

The loss of days or sessions is not ideal, although the training allows for sharing information for sessions missed via email notification. However, sharing missed information will enable the program to remain on schedule. Participants who missed sessions may become uninclined to complete an online review due to the sense of detachment throughout the training. On the other hand, participants who genuinely participated would be more inclined to complete all given tasks associated with the professional development training. To reduce the chances of missing training may come because of planning and scheduling with the local setting before the academic year starts.

Implementation and Timetable

The implementation process for the professional development program will occur over three full teacher workdays offered throughout the school academic year. There are scheduled times for October, November, and December. Participants will train from 9:00 am – 3:15 pm, with three separate scheduled breaks. The training will occur in the local setting at the school's principal. To consider a conducive learning space, the presentation needs, the number of participants, and classroom availability will be considered at the start of the academic year. The next step in planning the professional development is to design a schedule and overall plan to direct the efforts and resources required. Tables 3 and 4 show the first day of professional development on the background of the research and assess teacher participants' TPACK proficiencies using a self-assessment checklist (see Appendix J). This professional development will introduce the literature on developing technological knowledge (see Appendix K) to promote e-learning integration and close with a session that focuses on online networking, collaboration, and brainstorming mathematics software. The objective is to introduce teacher participants to TPACK and how it correlates with e-learning integration in the classroom using practical examples such as Microsoft Excel and Geo Gebra (see Appendix L).

Table 7

Section 1: Developing Technology Knowledge to Promote E-learning Integration and Self-Efficacy

Day 1 time	Topic	Resource
9:00 a.m.	Snack & welcome	
9:30 a.m.	Technological knowledge (presentation) & complete self-assessment checklist	Computers, writing pads, and pens, printed documents, a printer with ink
9:50 a.m.	Question & answers related to research	
10:00 a.m.	Content & Pedagogical Knowledge (presentation)	Computers, internet, smartboard/whiteboard
10:25 a.m.	Question & answers related to research	
10:30 a.m.	Task 1 Developing Self-efficacy: Technology integration scenario- Using spreadsheets, graphing software, geometry modeling software	Computers, writing pads and pens, scenario
11:00 a.m.	Pair discussion, classroom uses, and potential challenges	
11:15 a.m.	Break	
11:30 a.m.	Task 2: Reflecting the importance of TK and PK in mathematics instructions & session evaluation	Computers, evaluation forms, writing pads, and pens
12:00 p.m.	Lunch break	

Note. This table outlines the professional development activity for Session 1 during Day 1. Session 1 is online and focuses on developing technology knowledge to promote e-learning integration and self-efficacy.

Table 8

Section 2: Online Networking, Collaboration, and Brainstorming Mathematics Software

Day 1 time	Topic	Resource
1:00 p.m.	Online Networking (Presentation)	Computers, writing pads and pens, scenario, smartboard/whiteboard
1:30 p.m.	Q&A	
1:45 p.m.	Task 1: Introduction to Dr. Geo	Computers, writing pads and pens, scenario
2:00 p.m.	Task 1: Using Dr. Geo in the lesson Forms groups of pairs to discuss software, classroom uses, and potential challenges	Computers/ tablets Writing pads and pens Software evaluation checklist
2:20 p.m.	Task 2: Co-planning to integrate Dr. Geo in pairs	Computers, writing pads, and pens
3:15 p.m.	Break	
3:30 p.m.	Present outline for Dr. Geo lesson	Computers, writing pads, and pens
4:15 p.m.	Session evaluation & Session ends	

Note. This table outlines the professional development activity for Session 2 during Day 1. Session 2 is based on online networking, collaboration, and brainstorming mathematics software.

Table 9

Session 3: Planning for Content, Pedological, and Technological Knowledge to Promote E-learning Integration

Day 2 time	Topic	Resource
9:00 a.m.	Snack & welcome	
9:30 a.m.	Problem-Solving Techniques (Presentation)	Computer, internet, smartboard/whiteboard
9:50 a.m.	Questions & answers	
10:00 a.m.	Task 1: CSEC mathematics Questions: Spot the error & Make TPACK recommendations	Computer, internet, notepads & pens
10:45 a.m.	Break	
11:00 a.m.	Brainstorming: Using mathematics software Matrices	Computer, internet, notepads & pens, mathematics software
12:00 p.m.	Lunch	

Note. This table outlines the professional development activity for Session 23 on Day 2. The session facilitates activities related to planning for content, pedagogical, and technological knowledge to promote e-learning integration.

Table 10

Session 4: Blended Learning

Day 2 time	Topic	Resource
1:00 p.m.	Blend Learning (Presentation) Q&A	Computer, internet, smartboard/whiteboard
1:30 p.m.	Task 1: Plan e-learning lesson to address misconceptions made by students in CSEC mathematics (To use in an actual class)	Computer, writing pad, pens, internet
2:15 p.m.	Break	
2:30 p.m.	TPACK Survey/Questionnaire Lesson pre-evaluation (checklist) Sharing best practices	Computer/tablet/phone
3:15 p.m.	Session evaluation Session ends	Online form

Note. This table outlines the professional development activity for Session 4 on Day 2. The session facilitates activities related to blended learning.

During day three, participants engaged in assessment and feedback for session one and monitoring and evaluation for session two. Session one training allowed participants to use Microsoft applications and other applications to design learning tools suited for the mathematics lessons and engagement. In the second session, participants would develop a learning management system (LMS) to track students' strengths, weaknesses, improvements, and recommendations. These sessions consider problem-solving techniques used to solve mathematics exam-style questions and the use of mathematics-related software. Additionally, the second session focused on planning e-learning lessons and sharing best practices among participants. Also, participants will conduct a case study on students' performances in past examinations over ten years.

Table 11

Session 5: Assessment and Feedback

Day 3 time	Topic	Resource
9:00 a.m.	Snack & welcome	
9:30 a.m.	Using Microsoft Forms (Presentation)	Computer, internet, smartboard/whiteboard
10:00 a.m.	Creating a quiz using MS Forms	Computer, writing pad, pens, internet
10:45 a.m.	Break	
11:00 a.m.	Discussion points: ✓ Strengths ✓ Weakness ✓ Improvements ✓ Recommendations Using Kahoot	Computer/tablet/phone
12:00 p.m.	Lunch	

Note. This table outlines the professional development activity for Session 5 on Day 3.

The session facilitates activities related to assessment and feedback.

Table 12

Session 6: Monitoring and Evaluation

Day 3 time	Topic	Resource
1:00 p.m.	Monitoring and evaluation of student progress (Presentation) Introduction to Padlet Q&A	Computer, internet, smartboard/whiteboard, tablet computers/ smart mobile phone
1:30 p.m.	Task 1: Use a Ms. Excel to track student progress ✓ Strengths ✓ Weakness ✓ Improvements ✓ Recommendations	Computer, internet, notepads, pens
2:00 p.m.	Break	
2:15 p.m.	Task 1: Case study: Tracking students' performance in CSEC over ten years ✓ Brainstorming a case for e-learning ✓ Use figures & charts to represent data ✓ Reflections	Computer, internet, notepads, pens
3:15 p.m.	Session evaluation & self-assessment checklist Session ends	

Note. This table outlines the professional development activities for Session 6 on Day 3. This session facilitates activities related to monitoring and evaluation.

Role of the Researcher

The three-day blended professional development course design intends to deliver the training. However, it is possible for anyone with high levels of technology knowledge, such as an ICT teacher, to provide this training. Such a program design allows repeating the exercise with new teachers in subsequent years. Not all teachers are current with their understanding of e-learning and its practical use in mathematics lessons, which are vital for this study. Therefore, it is essential to have e-learning facilitators and curriculum specialists involved. The involvement of these specialists will ensure the representation of both areas and their skills used throughout the training. E-learning facilitators and curriculum specialists are also beneficial during the participants' reflective practice and best practice discussions. Teachers can use their advice to guide their teaching practice using technology.

Role of the Participants

Participants using e-learning in their mathematics will prioritize joining this blended professional development course due to the limited space available and the ongoing pandemic and host the training. Once these teachers have expressed their interest in joining, other teachers may fill open space in line with the pandemic guidelines. The design of the professional development activities will encourage teachers to discuss pedagogies they currently use, strengths and weakness with e-learning integration, and levels of self-efficacy. Teachers will also complete two self-assessments—one at the start and the next at the end of the training. Professional development is not presenter-directed training. Instead, it is a learning community where teachers share their best practices and engage in reflective practices to evoke new learning opportunities.

Project Evaluation Plan

A blended professional development is the chosen project. Evaluation of the professional development for the local setting will occur using a sequential evaluation framework commonly used for training programs. The review has four stages with the intention to measure (a) reactions, (b) learning, (c) behaviors and actions, and (d) results.

First, reaction measures participants' happiness, also known as 'happiness quotient. However, teachers must react positively to professional development for learning and behaviors to change. Second, learning measures how the professional development training improved teachers' knowledge and skills and changed their attitudes. The accomplishment of these learning objectives will lead to a change in instructional behaviors and actions among teachers. Third, behavior measures take place after a participant completes professional development training. However, the professional development instructor cannot effect change in participants unless they get that opportunity. Fourth, results measure the outcomes resulting from participants' participation in professional development.

To measure the outcomes and processes of the professional development, the devices used are (1) a questionnaire protocol containing open-ended questions and (2) a participant self-evaluation. These chosen devices are appropriate for the evaluation stages (reaction, learning, behavior, and results) (Evaluating professional learning a tool for schools and districts, n.d.). Although using a questionnaire may cause the participant to feel stressed and defensive, there are advantages to using a questionnaire. The questionnaire aids candid responses, provide summaries, miscommunication checking, and allows for in-depth probes. Like the questionnaire, self-evaluation has disadvantages. These disadvantages may include reliability and objectivity issues. However, it motivates participants to engage, a sense of professionalism and responsibility, encourages educators to focus on long-term goals and collaborates well with peer evaluation. A participant reflection evaluation is a participant reflection evaluation, according to

Petridou et al. (2015). The authors argued that feedback is a critical component of professional development, leading to enhanced training and support in the future. Additionally, participant reflection suggests how well the training met the needs of teacher participants. Thus, the combination of the questionnaire and the participant self-evaluation or reflection will provide an in depth and the opportunity to adapt training sessions for future cohorts.

Overall Goal of the Project

There are four parts to the overall project goals of the project. The project will provide opportunities for effective e-learning integration in mathematics courses by introducing web-based tools. Another goal is to identify and improve teachers' proficiencies in e-learning implementation. This goal fosters the development of teachers' self-efficacy and increases levels of TPACK through the integration and implementation of e-learning. The third goal facilitates teachers' ability to overcome the limits of e-learning integration. Teachers would engage in collaborative discussions to acquire new knowledge that fosters instructional strategies and best practices for technology integration. The fourth goal is to provide differentiated professional development for teachers in the local setting who desire ongoing e-learning training and development

Stakeholders

The local setting had no input in the design of the professional development program. However, these stakeholders played an essential role in the study. These stakeholders, through e-learning Jamaica, provided the opportunity for teachers to integrate and implement technology in their classrooms. As a result, they would be keen to know the potential benefits of e-learning integration to increase students' proficiencies and technology use across the curriculum. The research findings showed that teachers need systematic and well-organized professional development to bolster their individual needs. Thus, these stakeholders may find it advantageous to facilitate the study and the professional development to guide the e-learning provisions they offer their academic staff.

Most importantly, the teacher participants are vital stakeholders in this professional development course. The training program has a good impact on teachers' improvement. According to Valente (2020), professional development increases teacher knowledge. Additionally, the support teachers receive from professional development training encourages the ability of teachers to sustain what they learn in training. Similarly, teachers, through effective professional development, can develop transformative learning. According to Bonghanoy et al. (2019), transformative learning is a theory of adult learning that allows teachers to use questioning techniques to develop students' critical thinking skills. Teachers who participate can increase their knowledge and acquire students' thinking through effective teaching strategies. Teacher participation and feedback are advantageous for e-learning training improvements for new and existing teachers.

Project Implications

The blended professional development opportunity provided for teacher participants will help them identify and rectify their technology needs. Teachers will have a chance to expand their technical skills and transfer knowledge to students to improve their subject proficiencies. Students accessing technology integration in their lessons can solve problems using technology through skills acquired and build their capacity to learn more to concretize their content knowledge. Although technology is not widely accepted by all teachers as a means for classroom practice, allowing students to engage with its use would help develop good instructional practices and develop students as self-directed learners. Although technology in the classroom has advantages, its use may reflect a minimal change in the world and even no change in the local setting. Still, positive social change may emerge in the education sector and the wider community to provide better teaching resources for the local setting to enhance teacher morale to integrate e-learning through their subject courses for the benefit of all students.

The success of all students is vital for lifelong learning to occur, and it means that we should provide resources that challenge and engage diverse learners. According to Dewi et al. (2019), teachers equipped only with technical skills and not knowing how to integrate them in the classroom may overuse or underuse the true potential of technology integration learners. On the other hand, combining pedagogical and content knowledge alongside technology indicates success. It is an essential characteristic for their ongoing professional development. The professional development offered incorporates each aspect of the TPACK, and teachers are in all areas. Now, teacher participants from the local setting think professional technology development must be frequent to encourage sustained technological growth for classroom practice.

In the local setting, technology training is minimal, and teachers may choose to research technology-focused activities based on their interests. However, some students are issued tablet computers to use in their lessons. Minimal training is an apparent disconnect since training to effectively use these tablet computers is needed for teaching and learning. Nevertheless, teachers faced several obstacles of support and resources needed to use the e-learning devices successfully. Now, teachers' technology training is specific to online learning management systems. This training is shared among both local universities and overseas for all teachers. But teachers access to this professional development training may be hampered by their location or reliable technical devices and services. This training package includes Google Suite, Google classroom, science, technology, engineering, and mathematics (STEM) methodology. These offerings provide hope of changes to a more substantive push for technology integration and the development of teacher training to increase pedagogical knowledge.

Many teachers would agree that their students need extended learning opportunities in the classroom to be creative thinkers and learn how to use technology to collaborate and extend their learning. Acharya et al. (2021) stated that educators should use a culturally relevant pedagogical model in the classroom. A culturally pertinent model connects students' critical mathematical thinking and a critical view of knowledge. Still, we tend to forget that adult educators also need opportunities to become empowered professionals in their practice to support their students. The teacher education program should connect preservice teachers' mathematical experiences to the community and culture to understand fairness and justice. Teachers experiencing this education program work with students and use the best ways to integrate technology as a vehicle for collaboration, evaluation, and communication and should spend the time needed to grow professionally. Also, the view of mathematics should practically connect to students' life and culture, making it culturally relevant to what they do and must do as part of their everyday life. Consequently, teacher knowledge creates a school culture and learning environment that fosters e-learning implementation and integration.

Walden University provided a research committee that offered academic support. The research committee has experts who guide all doctoral candidates to complete the doctorate in the education program. I am happy with my chair and the second member who provided good quality feedback at each stage of the research process that led to the endpoint of the research. Other than the 3-day residency, the Doctor of Education (EdD) program occurred online. Our communications were very respective and aligned with Walden University's communication expectations between academic staff and students. The doctoral journey was challenging at times, and sometimes it was a case of stopping. However, my chair and second member motivated me to continue contributing to the education discipline through a project study geared towards students' improvement.

Section 4: Discussion, Conclusions, and Recommendations

I explored the perceptions of secondary mathematics teachers regarding their implementation of e-learning to teach mathematics and the support they receive in implementing e-learning in the classroom. Also, the study addressed the prolonged poor performance of Grade 11 students in their CSEC examinations. This section presents the strengths and limitations of the basic qualitative study and recommendations for future studies. I discuss the potential social change alignment with Walden University's mission and possible alternative solutions for addressing the problem beyond the scope of the project I presented. A comprehensive analysis of what I learned from conducting this study about the educational process addresses my project development and leadership. Also, I reflect on my practice as a doctoral student, a researcher, and an educator. I also present my overall reflection on the significance of my research, its implications, and directions for future research. I end this section with a summary of key points from my study.

Project Strengths and Limitations

Project Strengths

One strength of my project was the alignment of its design with the components described in the literature for establishing an effective and efficient blended learning professional development training for teachers implementing e-learning. Two research questions guided the study that explored secondary mathematics teachers' perceptions of the implementation of e-learning to teach mathematics and the support they receive to implement e-learning in the classroom. The TPACK theoretical framework grounded the study. Data collected for the study came from semistructured interviews. The findings indicated that teachers are willing to use e-learning in their lessons but need technology-based professional development training to enhance their implementation abilities. According to Lee et al. (2017), professional technology development impacts the likelihood of a shift in pedagogical practices. The current findings informed the development of the 3-day blended professional development course.

The 3-day blended professional development course was designed to be delivered in six half-day sessions based on the reported needs of teacher participants through semistructured interview responses. Teachers' needs are one of the course's strengths because teachers will receive vital support tailored to their technological needs. The basic qualitative study findings showed that teachers were at different self-efficacy levels using technology. Lee et al. (2017) and Meyers et al. (2016) argued that effective technology-based professional development training that is individualized improves learners' self-efficacy. Also, Lee et al. posited that a practical professional development course must examine ability levels to determine activities most suited to sustain teacher engagement throughout the training. The TPACK needs of teachers should inform the technology-based professional development (see Lai & Lin, 2018).

The 3-day blended professional development course will benefit the beginner, intermediate, and advanced teachers with e-learning implementation. This course design will allow teachers to collaborate regularly through online activities, sharing best practices, and department meetings. Mathematics teachers will have the opportunity to engage in collaborative inquiry geared toward effective technology-based instruction in their mathematics courses. During the collaboration, Trust et al. (2016) explained that teachers would assist each other in developing skills and knowledge needed to integrate and implement technology to help their instruction. Engagement in the 3-day blended professional development will allow teachers to be intrinsically motivated and engender capacity building and improved teacher self-efficacy. The course includes a curriculum and technology specialist to support teachers. Internal coaches could emerge among teachers to provide one-on-one assistance to their peers with effective e-learning in their mathematics courses (see Lai & Lin, 2018).

Another strength of the project is that it will work well with remote learning due to the COVID-19 pandemic. Health-related issues due to COVID-19 forced the local Ministry of Education and other arms of the Jamaican government to recommend remote learning for schools across the country. Teachers participating in this course will have the opportunity to use new knowledge learned in the online lessons and increase students' engagement (see Jones et al., 2021). According to Ryan and Sadler (2020), effective e-learning training will help teachers implement technology in their instruction and boost their self-efficacy. Another strength of the project is the potential impact the 3-day blended professional development will have on other regions where teachers have reported e-learning implementation limitations.

Project Limitations

The 3-day blended professional development course would be conducted in one school, focusing on secondary teachers' use of e-learning in their mathematics courses. Therefore, aspects of the study may not be transferable to subject disciplines. However, Parker et al. (2015) argued that technology-based professional development courses might be transferable to other school systems because the course is grounded in educational theory. Also, teachers' comfort levels with technology may influence their ability to implement e-learning, which is another limitation.

Recommendations for Alternative Approaches

I explored the perceptions of secondary mathematics teachers regarding their implementation of e-learning to teach mathematics and the support they receive in implementing e-learning in the classroom. An alternative approach to the study would be to examine the use of e-learning by mathematics teachers and students' achievement in mathematics using a mixed-methods approach. Researchers could collect quantitative and qualitative data over three academic terms in 1 year. The quantitative data would be pretest and posttest data to determine whether a correlation exists between e-learning implementation and mathematics achievement. Also, the study could be conducted in more than one school implementing e-learning in mathematics courses. Teachers in different schools may reveal other findings resulting from a different project. According to J. W. Creswell (2016), conducting the study in serval schools would transfer the findings to a more diverse sample of teachers. Another approach would be to extend the study to include all teachers at the school site. Teachers from other departments would benefit from technology training, particularly with the current teaching mode due to the pandemic. According to Burkholder et al. (2016), extending the study to the entire school would increase the sample size and the findings' reliability, credibility, and validity.

Scholarship, Project Development and Evaluation, and Leadership and Change

Scholarship

The degree process taught me about research and the research process. The courses I completed required considerable reading and critical thinking while developing my research skills to analyze other studies. Reading widely and continuously promoted my research knowledge. Examining research journals, writing literature reviews, and learning different research methods helped me produce a credible study. Before starting this journey, I observed limitations in mathematics instruction and wondered how to understand what was happening. I began to read journals about mathematics and decided to study at Walden University. While pursuing my first course, I registered for a 3-day residency in Arlington, Virginia, where I spoke to current students and faculty members who helped guide the direction of my research. I was able to decide on an issue but was informed that it would be time-consuming due to the rigor involved in the research process. During the research courses, I confirmed my research topic with the guidance of the university’s resources and course professors.

Although my doctoral journal was arduous during the proposal stage, my commitment to completing a task caused me to persevere. My journey taught me to manage time, think and write in a scholarly manner, and set measurable goals throughout the study. While researching literature for my local problem, I gained valuable knowledge and reviewed designs to lead to potential solutions. The most critical learning curve for me occurred during the IRB process. The IRB approval came after a constructive review of my research problem, the methodology, and the tools to conduct the research. Although collecting, organizing, and analyzing the data was challenging, the guidance of my chair and second member made it look easy. I learned that constructive comments motivated me to keep focused and keep going. I will endeavor to use constructive comments with my students to encourage them during the teaching and learning process. Also, I learned that researchers might go through several edits and changes within the research process before they become successful.

Project Development

For 16 years, I have been a mathematics and science teacher and a technology integration trainer staff for Mico University college and e-Learning Jamaica. During these adventurous years, I prided myself as an inquiry-based learner. I would observe a phenomenon and then seek answers through questioning and investigations. Depending on the phenomenon observed (e.g., mathematics instructional materials), I would introduce self-developed instructional materials in my mathematics lessons. I had no real plan or procedure but had a fragmented idea of investigating a problem without biased results. This project study developed my capacity to think critically and apply appropriate skills to guide my analysis of different research findings. While working on my prospectus, I researched literature aligned with my problem and the research questions. I was preparing to investigate a phenomenon in a discipline that appeared difficult and frightening at first. I was not sure how I could get this done in an unbiased and scholarly way. I read several secondary and primary studies to increase my objectivity to include related technological and educational theories. My objectivity in research studies started to develop after being exposed to qualitative research.

After completing the prospectus, I learned a valuable lesson about the research questions and the conceptual framework. According to Carl and Ravitch (2016), the research questions and conceptual framework ground the study. The research questions guide the data collection process, and the conceptual framework helps readers make sense of the problem studied by bridging the gap between theory and context. Although I was a novice in research, with the help of my chair and the second member, I used the TPACK conceptual framework to analyze the data collected. I learned that more goes into the project development than gathering evidence to support my research problem and questions. I used a preestablished questionnaire that was reliable and credible. I learned that the development of my project was not solely about completing an academic exercise but was a contribution to an ongoing discussion on e-learning integration in education and positive social change.

Leadership and Change

Leadership is a diversified phenomenon and exists throughout the education system. Critical thinking was the essential leadership feature to complete a task during my doctoral journey. Critical thinking helped me remove biases and develop an objective thought process. I conducted qualitative research and used the necessary thinking skills to analyze data to achieve an unbiased and credible study. Also, the essential thinking skills helped me analyze participants’ responses to identify themes that answered the research questions. Leadership features also include building staff capacity and promoting training and development to encourage motivation among staff. According to Yasir et al. (2016), motivating staff will facilitate positive change. Creating opportunities for others is also an essential feature of leadership. The project deliverable will allow experts in education technology to deliver the professional development course. To secure sustainability in education, training for future leaders is essential. Academic staff needs the opportunity to function as emergent leaders as they seek to achieve their full potential (see Yasir et al., 2016).

During this pandemic period, school leaders must reexamine and modify their current classroom instructions to meet the needs of their learners. During this research process, I communicated with the school leader and teacher participants, who agreed that classroom instruction required modification to deliver appropriate content and skills for learners. Distance learning forced education leaders to introduce emergency technology training for teachers to engage learners. Being a prospective leader, I became more aware of critical thinking skills when solving problems. Because teacher participants have long experienced deficiency in technology training, the blended professional development course should work well for the current situation. Teachers could use this training to enhance e-learning implementation in their mathematics courses.

Reflection on Importance of the Work

Analysis of Self as Scholar

As a novice in educational research, I realized that my research findings needed to be reliable, credible, and free from bias. I used a systematic and logical approach throughout. The academic experience gained at this level motivated me to build my capacity as a researcher in education. The continuous practice in education research may promote positive social change within the education system. The ability to complete an academic project study and contribute to education gave me a sense of self-actualization.

I look forward to implementing my professional development course at the research site. The process involved in this study required that I collaborate with practitioners like myself who supported my work and dedication to complete my educational journey. I worked with education researchers and a support network that provided continuous motivation at each stage of my doctoral journey. Constructive criticism came at each step, and though I felt frustrated at times, I kept my research focused and looked toward my success. My mindset developed over time, and I used feedback to build confidence as an aspiring educational researcher and scholar.

Analysis of Self as Practitioner

I have always wanted to be a teacher. My goal is to become a professor in education, and my doctoral journey is an indication that I can achieve. When I started my journey, I aimed to build my capacity to become a reliable academic scholar in education. This project study has made me a better practitioner. Noting that the alignment of curriculum, instruction, and assessment in school is essential, I widened my reading of relevant journals to improve my classroom practice through new ideas and methods. I now introduce new teaching strategies based on my understanding and reflect on my experience in my classroom. The recent knowledge gained came because of the critical thinking skills I developed. Having developed the necessary thinking skills, I now use more discussions in my lessons and ask students and teachers to use investigative questions during a discourse.

I used several academic journals during the project study. These journals helped me gain a comprehensive knowledge of education theories that guided the design of the blend professional development course. Education is a dynamic field, and being a lifelong learner is vital in coping with frequent changes in the educational community. I can connect theories and practice, which improves my pedagogy and leadership skills. I endeavor to engage my learners through inspirational instructions and learner-centered activities.

Analysis of Self as Project Developer

Although the education process started for me at age four, my academic journey began when I started my bachelor’s degree program in education six years before my doctoral journey. Being motivated, I started and completed my Master of Arts degree in education. In both degrees, I explored a broad problem that exists in education. During my doctoral study, I realized that my research was no longer looking at a more general educational problem but bridging a gap in knowledge about practice. Such research will enable me to contribute positively to the education field. As an aspiring professor in education, my interest was to apply my research to address a gap in professional practice in a local setting. I aimed to motivate mathematics practitioners to implement e-learning in their mathematics instructions.

The development of a project was not without challenges. To determine the best possible professional development, I had to read and re-read teacher participants’ responses, including notes from my researcher journal. The easiest part of the project’s design was an awareness that it needs a blended approach due to the current pandemic.

To understand what would work for teachers, I had to read extensively similar studies that connect to my research setting. After careful consideration, I decided to develop a 3-day professional development course. Considering the limitations of the pandemic and work engagement for teachers, I realized it was not feasible to deliver many workshops but instead six half-day professional development sessions. These six half day sessions will help teachers cope with the current situation as they learn new ideas. The entire process caused me to look beyond my intended accomplishment.

The Project's Potential Impact on Social Change

The potential of this project for social change is that teachers can develop sustainable and effective self-efficacy in e-learning implementation in their classrooms. Embedded in Walden University's mission and vision statements are positive social change. I have first-hand experience of Walden University training me to become a scholar, a practitioner, a project developer, and a leader of change. At first, the concept of social change seemed like a famous phrase developed by scholars to promote an agenda. However, Walden University equipped all students and faculty members with the knowledge and skills needed to improve and sustain the quality of 21st-century education. Throughout my academic journey at Walden University, I found myself tasked to fulfill its mission and vision, for which I do proudly and willingly. I pride myself as an agent of change who will continue to make myself available to engage in educational research that is keen to engender positive social change.

Doctoral research has great importance in developing and improving education in society. Education is a dynamic discipline and needs an active environment. The Walden

University doctoral program in education will achieve this type of environment. Our classrooms have diverse learners, and by acquiring new strategies, our lessons will be more engaging for all learners. I wanted to develop my Walden University doctoral program skills and knowledge to function effectively. I reviewed my curriculum for this doctoral program and confirmed that it was comprehensive and provided an abundance of knowledge and skills that prepared me to become a better leader.

Not all research had projects aligned to my research setting when this project began. Most research studies involved technology use in mathematics but did not explore how teachers implement the innovation. The research studies aligned with my project, and the research site were helpful and provided a context for my exploration. Implementing e-learning during this unprecedented time is paramount, but its integration and by who is equally important. Although the project opens the opportunity to observe how teachers use technology in their mathematics courses, it also creates the opportunity for teachers to get their students motivated in being self-directed learners. There is a more significant opportunity for growth and development of this type of research with this professional development course. The aim will be to train teachers and students to appreciate a more blended instructional approach across different subject disciplines.

Implications, Applications, and Directions for Future Research

This project study explored secondary mathematics teachers' perceptions of the implementation of e-learning to teach mathematics and their support to implement e-learning in the classroom. The study was limited to secondary mathematics teachers but may apply to other subject disciplines. Also, the study was conducted in an independent but may apply to another school system with a similar problem. There is prolonged poor performance of Grade 11 students in their mathematics examinations. Administering this study in another school system will require a specific focus on a primary, tertiary, and vocational institution.

Four major themes emerged from the research study. There was one minor theme. One of the significant themes indicated that secondary mathematics teachers needed frequent professional development to support e-learning integration. Other themes revealed benefits and problems to e-learning integration and barriers during technology integration. Also, there were concerns about teachers' proficiency in e-learning implementation. The requirement of teachers to integrate technology in their mathematics lessons with adequate training was a challenge for these teachers. Therefore, the connection between technology and training suggests a change in basic assumptions in the teachers' use of e-learning tools based on the level of their e-learning training. The data showed that teachers who received specific e-learning training could implement that technology in their lessons—after its introduction, implementing a piece of technology implies a relationship between e-learning and teachers' proficiencies.

Six mathematics teachers benefited from the 3-day blended professional development course. However, this course may be practical for teachers in other academic disciplines who have challenges implementing technology. Although I limited the 3-day blended professional development to an independent school, I recommend conducting future research to extend this study to other schools and subject disciplines. The basic qualitative research study addressed a problem within an urban secondary school regarding mathematics teachers implementing e-learning in the classroom. I would also recommend using quantitative research methods to investigate how teachers use e-learning and the frequencies of its implementation in their instructions. A researcher could then use correlation research to note the degree to which variables correlate. The 3-day blended professional development course focused on using an internal curriculum specialist and an education technology expert to lead the training. I would recommend using suitable models to deliver technology-based professional development to teachers.

Conclusion

Section 4 of the project study presented the project strengths and limitations, recommendations for alternative approaches and scholarship, project development, and leadership. I reflected on the importance of work. I reflected on myself as a scholar, a practitioner, and a project developer. Also, I outlined the project's potential impact on social change and, finally, the implications, applications, and directions for future research.

The project study explored secondary mathematics teachers' perceptions of the implementation of e-learning to teach mathematics and their support to implement e-learning. The findings indicated that e-learning implementation in mathematics instructions improves when teachers receive training and support. According to Sprott (2019), teachers who receive training and support in implementing technology in their instructions facilitate skill development required to respond to the 21st-century classroom. Teachers need relevant technological training with new software and hardware to deliver mathematics content and meet the needs of learners. The findings showed that teachers are willing to learn and use new technological ideas, but the training and development are not forthcoming. The Jamaican government closed the physical space for all schools to protect teachers and students. The requirement was for school administrators to use remote learning to implement the curriculum and engage learners. Remote learning was inevitable but proved challenging for less technology-savvy students and teachers. Limiting the challenge felt by teachers, the government provided emergency technology training for teachers to use specific online platforms curriculum, instructions, and assessment. This unprecedented phenomenon confirmed the need for a blended approach to teaching in the 21st-century classroom.

I used a qualitative methodology to collect and analyze secondary mathematics teachers implementing e-learning in their mathematics instruction and support. The interaction with these teachers opens the opportunity to release that curriculum, instructions, and assessment are interdependent. A core tenet of critical epistemology is the production of just representations of participants' own lived experiences (see Carl & Ravitch, 2016). Also, memos allow the researcher to reflect intentionality and fidelity on the alignment of critical epistemology with research realities. Interviewing participants gave first-hand insight into teachers' perceptions of implementing e-learning in their mathematics courses and the support they need. The recommendations of the research study have the potential to empower secondary school teachers to become technology literate to meet the needs of the 21st-century classroom and learners. Improving teachers' self-efficacy with technology implementation school-wide is essential for achieving positive social change in education. An improved self-efficacy is crucial since teachers will enhance their ability to implement e-learning to improve students' mathematics proficiencies. Also, it is vital to equip students with 21st-century skills to adapt and function in a changing world. According to Francis (2017), to create an effective 21st-century classroom that meets the needs of learners, the modern teacher must identify what motivates students to learn and the effects technology has on inclusionary education.

The journey and completion of a doctorate in education require more than tenancy, dedication, and hard work. Emotional support is paramount is vital to the completion of the Doctorate in Education program. Walden University provided a research committee that offered academic support for all doctoral candidates as part of my doctorate in the education process. I am happy with my chair and the second member who provided good quality feedback at each stage of the research process that led to the endpoint of the research. Other than the 3-day residency, the Doctor of Education (EdD) program occurred online. Our communications were very respective and aligned with Walden University's communication expectations between academic staff and students. The doctoral journey was challenging at times, and sometimes it was a case of stopping. However, my chair and second member motivated me to continue contributing to the education discipline through a project study geared towards students' improvement.

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Appendix A: The Project

Implementing E-learning in Mathematics: Developing Content, Pedagogical, and Technological. Knowledge.

Purpose:

The purpose of the three-day blended professional development course is to provide CSEC mathematics teachers with the opportunity to be involved in a collaborative e-learning community. The program will help develop required content, technological, and pedagogical knowledge to implement content-specific mathematics e-learning tools in their classroom. The findings of my study indicated that there are in-school and out-of-school barriers that negatively impact the e-learning implementation in mathematics. Although serval barriers emerged, PD was a key concern among all teachers. PD would help with collaboration among teachers, communication with parents and students, research, and planning. This plan would expose teachers to additional mathematics programs. A teacher could use the software to develop students' mathematics proficiencies. Meanwhile, teachers will build their pedagogical and technological knowledge. Consequently, the teacher could use the new ability to plan for diverse learners using appropriate instructions to address their needs.

Stated Goals:

1. Provide differentiated professional development to all teachers who use or want to use e-learning in their classroom and have not been provided with e-learning training that meets their individual needs. All participants mentioned a lack of professional development targeting their specific needs; this project will address those interviewees' concerns.
2. To encourage co-teaching, co-planning, and collaboration among secondary teachers to promote mathematics and technology integration skills effectively.
3. To promote the development of TPACK among teachers that reduces limits to technology integration in their mathematics courses. A positive professional development outcome would be for participants to see an increase in self-efficacy at the close of the school year
4. To demonstrate that e-learning can enhance secondary students' mathematics proficiencies. The literature indicates that technology integration is commonly studied in mathematics compared to other subject areas, so this goal is to confirm the knowledge base on this topic.

Implementation Schedule: Blended PD for Mathematics Teachers

Day 1: TPACK and collaboration in mathematics

Session 1: Introduction to Content, Pedagogical, and Technological knowledge to promote E-learning Integration

Session 2: Online Networking, collaboration, and Brainstorming Mathematics Software

Duration: 3 hours

Day 2: Integrating TPACK in Mathematics Lesson Planning
Session 3: Planning for Content, Pedagogical, and Technological Knowledge to promote E-learning Integration
Session 4: Blending Learning
Proposed time: October PD Day
Duration: 09:00-15:15

Day 3: Evaluating e-learning in Mathematics Instructions
Session 5: Assessment & Feedback
Session 6: Monitoring & Evaluation
Duration: 09:00-15:15

The timetables (Days 1-3) show the breakdown of each PD session. The times proposed for the sessions align with the current procedures for PD at the urban secondary school. Due to a pandemic, these times may vary based on school administrative procedures or disruption. Changes in times may cause a session(s) to be removed, shortened, or lengthened. The second column explains the breakdown of the PD activities, and the third column outlines the resources needed for each activity.

Day 1

Session 1: Developing Technological Knowledge to promote E-learning Integration
Table 3
Professional Development Timetable for Session 1

Time	Topic	Resources
09:00	Snack & welcome	
09:30	Technological knowledge (presentation) & TPACK self-assessment	Computers, writing pads, and pens
09:50	Question & answers related to research	
10:00	Content & Pedagogical Knowledge (presentation)	Computers, Internet
10:25	Question & answers related to research	
10:30	Task 1: Technology integration scenario- Using spreadsheets, graphing software, geometry modeling software	Computers, writing pads and pens, scenario
11:00	Pair discussion, classroom uses, and potential challenges	
11:15	Break	
11:30	Task 2: Reflecting the importance of TK and PK in mathematics instructions & session evaluation	Computers, evaluation forms, writing pads, and pens
11:00	Lunch Break	

Session 2: Online Networking, collaboration, and Brainstorming Mathematics Software
Table 4
Professional Development Timetable for Session 2

Time	Topic	Resources
12:00	Networking through collaboration (Presentation)	Computers, writing pads and pens, scenario, Internet access
12:30	Q&A	
12:45	Task 1: Introduction to Nearpod	Computers, writing pads and pens, scenario
13:00	Task 1: Using Nearpod in lesson ✓ Forms groups of pairs to discuss Nearpod, classroom uses, and potential challenges	Computers/ tablets Writing pads and pens Software evaluation checklist
13:20	Task 2: Co-planning to integrate Nearpod in pairs	Computers, writing pads, and pens
14:15	Break	
14:30	Select mathematics and present using Nearpod	Computers, writing pads, and pens
15:15	Session ends	

Day 2

Session 3: Planning for Content, Pedagogical, and Technological Knowledge to promote E-learning Integration

Table: 5

Professional Development Timetable for Session 2

Time	Topic	Resources
09:00	Snack & welcome	
09:30	Problem solving techniques (Presentation)	Computer, Internet
09:50	Questions & answers	
10:00	Task 1: CSEC mathematics Questions: **Spot the error** & Make TPACK recommendations	Computer, Internet, Notepads & pens
10:45	Break	
11:00	**Brainstorming: Using mathematics software** Venn diagram Algebraic Expressions & equations Linear graph	Computer, Internet, Notepads & pens, Mathematics software
12:00	Lunch	

Session 4: Blending Learning

Table: 6

Professional Development Timetable for Session 2

Time	Topic	Resources
13:00	Blend learning (Presentation) Q&A	Computer, Internet
13:30	Task 1: Plan e-learning lesson to address misconceptions made by students CSEC mathematics (To use in an actual class)	Computer, writing pad, pens, Internet
14:15	Break	
14:30	TPACK Survey/Questionnaire	Computer/tablet/ Phone

	Lesson pre-evaluation (checklist) Sharing best practices	
15:15	Session evaluation Session ends	

Day 3

Session 5: Assessment and Feedback

Table: 7:

Professional Development Timetable for Session 5

Time	**Topic**	**Resources**
09:00	Snack & welcome	
09:30	Using Microsoft Forms (Presentation)	Computer, Internet
10:00	Creating a quiz using MS Forms	Computer, writing pad, pens, Internet
10:45	Break	
11:00	Discussion points: ✓ Strengths ✓ Weakness ✓ Improvements ✓ Recommendations Using Kahoot	Computer/Tablet/ Phone
12:00	Lunch	

Session 6: Monitoring and Evaluation

Table: 8

Professional Development Timetable for Session 6

Time	**Topic**	**Resources**
13:00	Monitoring and evaluation of student progress (Presentation) Q&A	Computer, Internet
13:30	Task 1: Use a Ms. Excel to track student progress ✓ Strengths ✓ Weakness ✓ Improvements ✓ Recommendations	Computer, Internet, notepads, pens
14:00	Break	
14:15	Task 1: Case study: Tracking students' performance in CSEC over ten years ✓ Brainstorming a case for e-learning ✓ Use figures & charts to represent data ✓ Reflections	Computer, Internet, notepads, pens
15:15	Session evaluation Session ends	

Appendix B: Cover Letter

RE: Invitation to participate in a research study
Name,

I am currently starting my doctoral research study, having received Walden University's Institutional Review Board approval. It was observed that your school is presently using e-learning in mathematics lessons, especially among final year (Grade 11) students. My research study will attempt to explore the instruction occurring in the e-learning mathematics initiative through teachers' perspectives to understand better how they implement instruction in the e-learning mathematics initiative courses. This letter is an invitation to allow you, mathematics teachers, to share their knowledge on this research topic.

I am looking for mathematics teachers who have used e-learning in mathematics instructions for at least three years in selecting participants. The study will use a qualitative interview at a time and location (in person, phone, or Skype) convenient to you. I will also use a researcher's journal to collect secondary data of 'participants' experiences, expressions, and observations identified during the interview process.

If you have an interest in participating in this study, please respond to this e-mail. If you need further clarifications, feel free to contact me at the Email

(gladstone.faulknor@waldenu.edu)
Respectfully,
Gladstone A. Faulknor

Appendix C: Interview Protocol

I would like to express my appreciation for you taking the time and sharing your knowledge on this subject. As I mentioned previously, the purpose of this project study was to explore secondary mathematics teachers' perceptions on the implementation of e-learning to teach mathematics and the support they receive to implement e-learning in the classroom. You consented to participate in this research study. If you agree to be interviewed, please state your name and that you agree. If you wish to conclude this interview or have the recording stopped at any time, you may do so.

Definition of term:

The Technological Pedagogical Content Knowledge (TPACK) is a conceptual framework that explains technology's integration in the classroom, particularly in mathematics.

Interview data points yield questions

1. What are your thoughts on using e-learning in your mathematics courses?
2. How do you use e-learning in your mathematics courses?
3. How do you adapt your teaching using e-learning based on what students understand or do not understand during your lesson?
4. How do you select e-learning tools for teaching mathematics?
5. How have you used e-learning as a digital tool to meet your school mathematics learning outcomes and students' learning experiences?
6. How would you describe your knowledge of e-learning in mathematics instruction?
7. What changes have you made to your instructions to incorporate the use of e-learning in mathematics courses?
8. How would you describe your ability to use e-learning tools in your classroom to enhance what students learn?
9. How does e-learning enhance mathematics content delivery in your classroom?
10. How do you use e-learning to address students' alternative conceptions in your mathematics courses?
11. How do you use e-learning to facilitate students' understanding of challenging mathematics concepts?
12. How have you maintained classroom management when using e-learning in your mathematics courses?
13. How would you describe the conduciveness of your mathematics classroom during the use of e-learning?
14. What factors influenced the implementation of e-learning in your mathematics course? Why?
15. How has the use of e-learning affected students' mathematics knowledge?
16. How would you describe your ability to provide leadership in helping other teachers coordinate e-learning in their lessons?
17. How does e-learning use in your mathematics courses encourages students' discourse in the lesson?

18. How do you use e-learning to assess students' progress during the learning process in your mathematics lessons? How has the use of e-learning in your mathematics courses affected your students' mathematics assessment performance?
19. How would you describe your student's attitude towards the use of e-learning in their mathematics lessons?
20. What professional development did you receive that allows you to implement and teach e-learning in mathematics?
21. How has the professional development you receive improved your knowledge of e-learning use in mathematics?
22. How would you describe the frequency of professional development you have received that allows you to use e-learning in mathematics?

Thank you for your time and for sharing your experience with me. All personal information, including your name and institution, will be removed before the analysis begins. Again, I appreciate your time and cooperation in pursuing this research.

Respectfully,
Gladstone A. Faulknor

Appendix E: Selection Letter

Gladstone Faulknor {Date}

RE: Selection of participants in the research study

Name,

Congratulations! You were selected to participate in this study. If you are still interested in participating in this study, I would like to set up a time for your interview. Please send a time, date, and location you are available to be interviewed. As I live in the area, the interview method can be in-person, by phone, or by Skype.

I thank you for your willingness to participate, however, I would also remind you that you can decline to participate at any time.

I will record all interviews followed by transcription of the data. I will provide you with a copy of the research study when it is completed if you are interested.

Respectfully,
Gladstone A. Faulknor
876.574.2982
gladstone.faulknor@waldenu.edu

Appendix F: Relationship of Interview Questions to Research Question and Conceptual Framework Selection Letter

Technology integration questions.

These questions are meant to put the participants at ease, develop the participant's awareness of the interview process, create a relationship between the participant and myself, and have freedom of speech (relevant to the interview question).

1. What do you understand by the term technology integration?
2. What role does technology play in mathematics education?
3. What is your knowledge of e-learning?

Research question 1.

1. What are secondary mathematics teachers' perceptions on the implementation of e-learning to teach mathematics?

Conceptual framework	Interview question	Relationship
TPACK	What are your thoughts on the usefulness of e-learning in your mathematics courses?	Pedagogy knowledge Technological knowledge Content knowledge
	How do you use e-learning in your mathematics courses?	Pedagogy knowledge
	How do you adapt your teaching using e-learning based on what students understand or do not understand during your lesson?	Technological knowledge
	How do you select e-learning tools for teaching mathematics?	Technological knowledge
	How have you used e-learning as a digital tool to meet your school mathematics learning outcomes and students' learning experiences?	Pedagogy knowledge Technological knowledge
	How would you describe your knowledge of e-learning in mathematics instruction?	Technological knowledge

	What changes have you made to your instructions to incorporate the use of e-learning in mathematics courses?	Pedagogy knowledge
TPACK	How would you describe your ability to use e-learning tools in your classroom to enhance what students learn?	Pedagogy knowledge Technological knowledge
	How does e-learning enhance mathematics content delivery in your classroom?	Content knowledge
	How do you use e-learning to address students' alternative conceptions in your mathematics courses?	Pedagogy knowledge Content knowledge
	How do you use e-learning to facilitate students' understanding of challenging mathematics concepts?	Pedagogy knowledge Content knowledge
	How have you maintained classroom management when using e-learning in your mathematics courses?	Pedagogy knowledge
	How would you describe the conduciveness of your mathematics classroom when using e-learning?	Pedagogy knowledge Technological knowledge Content knowledge
	What factors influenced the implementation of e-learning in your mathematics course? Why?	Pedagogy knowledge Technological knowledge Content knowledge
	How has the use of e-learning affected students' mathematics knowledge?	Pedagogy knowledge
	How would you describe your ability to provide leadership in helping other teachers coordinate e-learning in their lessons?	Pedagogy knowledge Technological knowledge Content knowledge
	How does e-learning use in your mathematics courses encourages students' discourse in the lesson?	Pedagogy knowledge

	How do you use e-learning to assess students' progress during the learning process in your mathematics lessons? How has the use of e-learning in your mathematics courses affected your students' mathematics assessment performance?	Pedagogy knowledge Technological knowledge Content knowledge
	How would you describe your students' attitude towards e-learning in their mathematics lessons?	Pedagogy knowledge

Research question 2.

What support do teachers perceive is needed for secondary mathematics teachers to implement e-learning in the classroom?

Conceptual framework	**Interview question**	**Relationship**
TPACK	What professional development did you receive that allows you to implement and teach e-learning in mathematics?	Pedagogy knowledge Technological knowledge Content knowledge
	How has the professional development you receive improved your knowledge of e-learning use in mathematics?	Pedagogy knowledge Technological knowledge
	How would you describe the frequency of professional development you have received that allows you to use e-learning in mathematics?	Technological knowledge

Appendix G: Permission Correspondence to Use Interview Protocol

From: disspub@proquest.com
Sent: Tuesday, June 23, 2020 4:09 AM
To: faulknorg@outlook.com
Subject: RE: Permission to use Interview protocol

Hi Gladstone,

I hope this email finds you well. If you are using a dissertation or research all you need to do is properly cite your source and you are permitted to use it.

Kind Regards,
Carl Mageski – Author & School Relations
ProQuest | 789 E. Eisenhower Parkway | Ann Arbor, MI USA 48106-1346 | 800-521-0600 press 2, then 1

--------------- Original Message ---------------
From: Gladstone Faulknor [faulknorg@outlook.com]
Sent: 6/22/2020 5:52 PM
To: disspub@proquest.com
Subject: Permission to use Interview protocol

CAUTION: EXTERNAL Email.

Good evening,

I am Gladstone Faulknor. How do I go about getting permission to use an interview protocol for my research?

Thank you

Gladstone Faulknor

Sent from Mail for Windows 10

Appendix H: Themes and Perceptions of Teachers Connected to Research Question

RQ1. What are secondary mathematics teachers' perceptions on the implementation of e-learning to teach mathematics?	
Themes	Pseudonyms and perceptions
Theme 1. Benefits and problems with elearning integration in mathematics.	**Participant 1**. "The use of technology will help to enhance the retention of the work among students," "Technology helps to increase their participation as they can use both synchronous and asynchronous means access the materials," "eventually improving their mathematics knowledge.", "I would call them 'technology children' as they will engage with the technology," "using the graphing software, they become more engaged in the lesson," "It helps me to use more videos in lessons and different online games," "Google forms. This platform helps me track their participation and task completion" "Using technology at the start of the lesson helps me a lot." "technology will help them to get more practice and help them to retain," "We can now use the Quizzes or live worksheet," "for their misconceptions, immediately I will explain using an e-learning platform. They would watch a relating video." **Participant 2** "Computers are available, but they are without useful mathematics software or reliable additional peripheral to make mathematics lessons useful" "new software elicit discourse in the lesson among students as they would be curious how it works. ", "students initially have a positive attitude to the use of e-learning in lessons," "they will become more engaged and have continued positive attitude," "I use reinforcement in technology-based lessons to address possible misconceptions," "The software allows students to work independently and allows them to address their misconceptions." **Participant 3** "It is vital," "Some students love it, some students do not have reliable Internet and electricity," "Based on the unit/topic and select the best tool. Suitable technology tools for topic", "students are drawn to technology, leave from teacher-centered to student-centeredness," "Students become excited when they go to the computer lab and always have positive feedback," "help them to achieve that outcome," "mathematics software help students' interaction and their understanding of the concept," "students will watch a video aligned with the lesson to address misconceptions," "I use the technology to explain challenging concepts to students." **Participant 4**. "stimulate the students to ask questions: students have more experience when they interact with content," "e-learning allows you to explore. Be a Facilitator," "students can be fully engaged by exploration: - through critical thinking, creativity, collaboration, and communication," **"**To achieve equity, you need to teach to the diverse learners**"** "liveworksheet.com: interactive worksheet with instant feedback," "E-learning allows you to identify the quality of knowledge through assessments. Instant feedback quickly.," "Students love to be in charge/engaged," "workshop allowed me to be informed: allows for engagement, collaboration, active participation," "learner is more involved," "I use math learning center website: Student would manipulate fractions using the website: use the manipulative to delete misconceptions conceived by students." **Participant 5** "Mathematics is about problem-solving give them a scenario using technology for them to solve," "use the tools to solve the problem and engage in group discussion," "e-learning enhance the lessons, engagement, students interested," "the lesson should cater for all learners" "learning software would help students to identify," "I would need to find the right videos; step by step to grasp the concept," "live whiteboard allows me to be flexible in bringing across the lesson." **Participant 6** "online quizzes-provides immediate feedback," "Students are more engaged in the lesson; It opens my knowledge base," "e-learning in mathematics has improved my teaching overall," "All must have an opportunity to learn." "help them to develop a routine with the technology being used," "they will apply technological skills

	needed to manipulate the technology," "view videos independently; help them to understand the concept.," "if one class has a misconception, you can find another clip-that explains more simply."

Appendix H: (continued)

RQ1. What are secondary mathematics teachers' perceptions on the implementation of e-learning to teach mathematics?

Themes	Pseudonyms and perceptions
Theme 2. Teachers perceive their proficiency in elearning implementation. **Subtheme:** Elearning tools teachers need to access for planning and mathematics instructions	**Participant 1**. "I would say it is about average," "I am moderate with the use of e-learning "I am still in the process of learning." "This platform also provides analysis of what students have produced," "when technology is involved, classroom management is easier," "use different games like quizzes online with students," "we do give them a lot of quizzes," "I use Google Classroom and Zoom to deliver lessons," "If readily available, I will use the smartboard." **Participant 2**. "I try to keep myself current with new technological development," "I am giving myself 91%", "compare students' abilities among different topics and for further analysis," "individualized analysis for each student," "I will send my classroom expectations," "test and quizzes help us to note trends." **Participant 3** "I am at the moderate level. I am still researching technology integration," "I manage physical interference with technology," "Collaborative effort; you manage to meet the expectations," "I use quizzes online using google classroom as it produces scores." **Participant 4**. "more than average: very good knowledge of technology integration," "my knowledge is 8.5/10", "Once they are manipulating the tool it is 10/10", "without technology it is more tedious to gather and analyze data," "Zoom allows for greater control in the virtual space. Raising hands feature," "improve another teacher knowledge through collaborative teacher forum," "I use Schoology," "Wrenweb allows you to keep a record of students' progress," "I would create different documents in excel for students to do the calculation." **Participant 5** "7/10; lots more needs to be done", "room for learning," "competent in using e-learning in the classroom," "I set out my expectations and consequences," "Collaboration among the teachers," "I use Google suite," I use Schoology." **Participant 6**. "I learn by doing," "I teach myself. I find it easy", "You can do a diagnostics/survey," "you will have an idea based on analysis," "To manage my classroom, I would use support materials for faster students," "online quizzes-provides immediate feedback to kids.", I use Google classroom," "You could allow students to use the smartboard," "They can use their tablets to answer the questions," "I used MS Excel to create an interactive worksheet," "Schoology, Edmodo, and Moodle system can all be used asynchronously."

RQ1. What are secondary mathematics teachers' perceptions on the implementation of e-learning to teach mathematics?

Themes	**Pseudonyms and perceptions**
Theme 3. Teachers experience barriers during elearning integration.	**Participant 1.** "You will have the videos that you can prepare, but the only thing is if there is reliable Internet or electricity.", "difficult sometimes with the materials in the room or the availability of tools," "we have different types of learner so some persons may not feel comfortable using technology and may get put off," "some of the tools that you would want is not readily available."

	Participant 2. "the resources are lacking," "PD training is lacking," "get chaotic at times since everyone may want to use the limited resources," "there are topics that the current e-learning tools are unable to explain." **Participant 3.** "Not all software help with a specific topic," "COVID pandemic- reduces the social interaction," "PD training is not frequent," "once electricity and Internet are working." **Participant 4** "Accessibility to Internet/devices- no money to purchase other materials," "Workshops were not tailored to teaching mathematics," "PD is not frequent," "I depend more on other mathematics teachers than getting formal PD.", "7 out of 10: some students do not have device/Internet access", "Without e-learning, it would be 3 out of 10." **Participant 5.** "Different types of learners," "we do not get enough PD," "we need to look at PD training," "classroom, not conduciveness," "not all students have access to Internet/devices." **Participant 6.** "Learning styles, time frame for syllabus completion, and student level of interest," "Not frequent," "The government do not provide continued e-learning training through JTC."

RQ2. What support do teachers perceive is needed for secondary mathematics teachers to implement e-learning in the classroom?

Themes	**Pseudonyms and perceptions**
Theme 4. Professional development is needed to support elearning integration	**Participant 1**. "Communication with students and parents." **Participant 2**. "Mathematics software needed," "to be honest, there should be a teacher upgrade every five years.," "Teachers need more ICT training in technology integration and exposure," **Participant 3.** "reliable Internet and electricity are needed," "Collaboration among teachers in the department." **Participant 4** "E-learning material needed," "Communication with parents.", "We need more training to use the technology." **Participant 5** "the classroom needs upgrading," "ICT workshops are needed in the district and region," "teachers need specific training to help them based on their specific needs.", "Students need access to Internet and Devices." **Participant 6** "we need more e-learning training."

Appendix I: Relationship of Interview Questions to Research Question and Conceptual Framework Selection Letter

Member check questions of interview transcript	Does the transcript reflect and resonate with your perspective? How might it differ, and why? • Is there anything that this transcript does not capture?
Member check questions of analysis codes	Is there anything you think I should consider in my analysis? • Is this how you would categorize this idea or concept? • Do these codes make sense to you? • Do these code definitions resonate? Why or why not?
Member check questions of findings	Do these findings resonate with you? • What could I change or add to make them more accurate? Are there any assumptions or biases? • Are my descriptions appropriate and accurate?

Notes. Adapted from Sage Journal Birt, L., Campbell, C., Cavers, D., Scott, S., Walter, F. (2016).

Appendix J: Blended Professional Development Resources

Day 1- Teacher Participants TPACK Self-Assessment Proficiencies

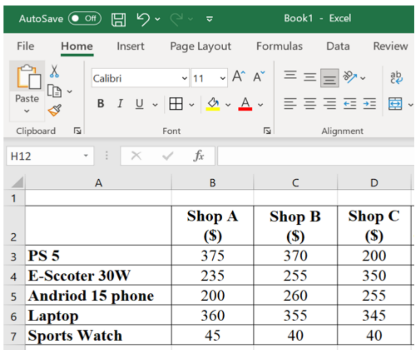
	SA	A	NS	DA	SDA
PK 1: I have a clear understanding of pedagogy (e.g., designing instruction, assessing students' learning)					
PK 2: I am familiar with a wide range of practices, strategies, and methods that I use in my teaching					
PK 3: I know how to assess student learning.					
PK 4: I know how to motivate students to learn.					
TK 5: I am familiar with a variety of hardware, software, and technology tools that I can use for teaching.					
TK 6: I know how to troubleshoot technology problems when they arise.					
TK 7: I can decide when technology can be beneficial to achieving a learning objective.					
CK 8: I have a comprehensive understanding of the curriculum I teach.					
CK 9: I explain to students the value of knowing concepts in my discipline.					
CK 10: I make connections between the different topics in my discipline.					
: PCK 11: I understand that there is a relationship between content and the teaching methods used to teach that content.					
PCK 12: I can anticipate and address students' preconceptions and misconceptions.					
PCK 13: I understand what topics or concepts are easy or difficult to learn.					
TPK 14: I understand how teaching and learning change when certain technologies are used.					
TPK 15: I understand how technology can be integrated into teaching and learning to help students achieve specific pedagogical goals.					
TPK 16: I know how to be flexible with my use of technology to support teaching and learning.					
TCK 17: I understand how the choice of technologies allows and limits the types of content ideas that can be taught.					
TPACK 18: I integrate educational technologies to increase student opportunities for interaction with ideas					
TPACK 19: I motivate my students to use learning technologies to support their individual learning					
TPACK 20: I understand what makes certain concepts difficult to learn for students and how technology can be used to leverage that knowledge to improve student learning.					
TPACK 21: I understand how to integrate technology to build upon students' prior knowledge of curriculum content					
TPACK 22: I know how to operate classroom technologies and can incorporate them into my discipline to enhance student learning					

SA- strongly agree **A**-Agree **NS**- Not sure **DA**- disagree **SDA**- Strongly disagree

Note. Adapted from *Teaching approaches and educational technologies in teaching mathematics in higher education,* by Alonso I.G, Ammenwerth E., Feuerstein, E., González, R.T., Hackl, W, O., Nantschev, R., Petridis, K. & Triantafyllou, E., 2020, p.8.

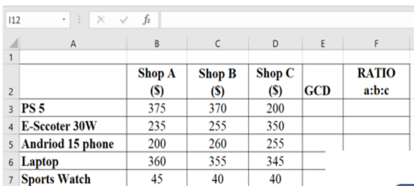
Integrating technology Mathematics: Using Microsoft Excel

1. Using spreadsheet GCD coding to solve ratio problems



	Shop A ($)	Shop B ($)	Shop C ($)
PS 5	375	370	200
E-Sccoter 30W	235	255	350
Andriod 15 phone	200	260	255
Laptop	360	355	345
Sports Watch	45	40	40

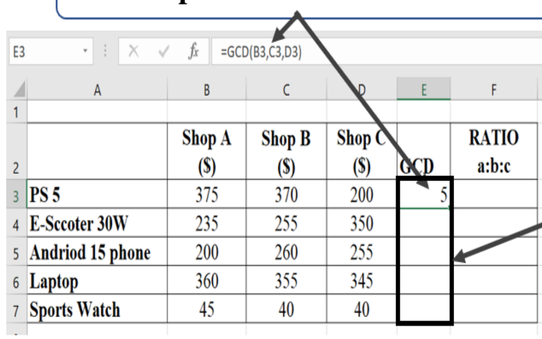
Step 1: Open Ms Excel & create a table as seen. Add the information to each cell based on your question.



	Shop A ($)	Shop B ($)	Shop C ($)	GCD	RATIO a:b:c
PS 5	375	370	200		
E-Sccoter 30W	235	255	350		
Andriod 15 phone	200	260	255		
Laptop	360	355	345		
Sports Watch	45	40	40		

Step 2: Add two columns as seen. Label each accordingly.

Step 3: Add this formula to **E3**.

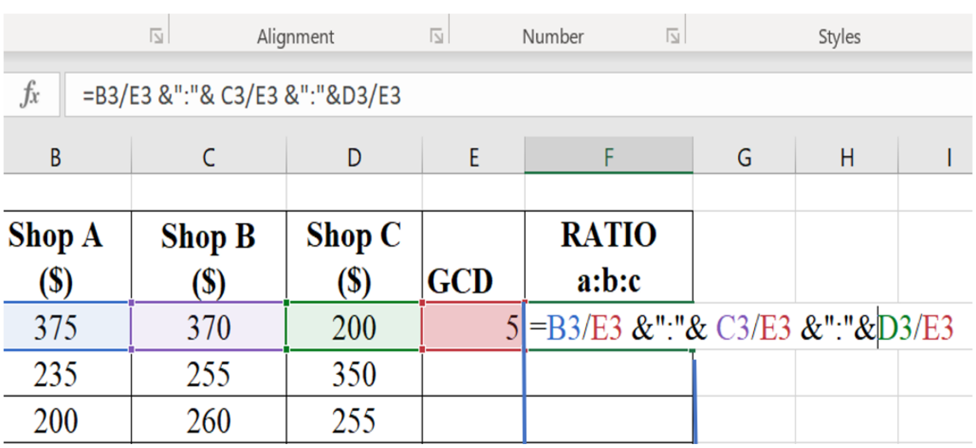


=GCD(B3,C3,D3)

	Shop A ($)	Shop B ($)	Shop C ($)	GCD	RATIO a:b:c
PS 5	375	370	200	5	
E-Sccoter 30W	235	255	350		
Andriod 15 phone	200	260	255		
Laptop	360	355	345		
Sports Watch	45	40	40		

Step 4: copy the formulae (D3 to D7)

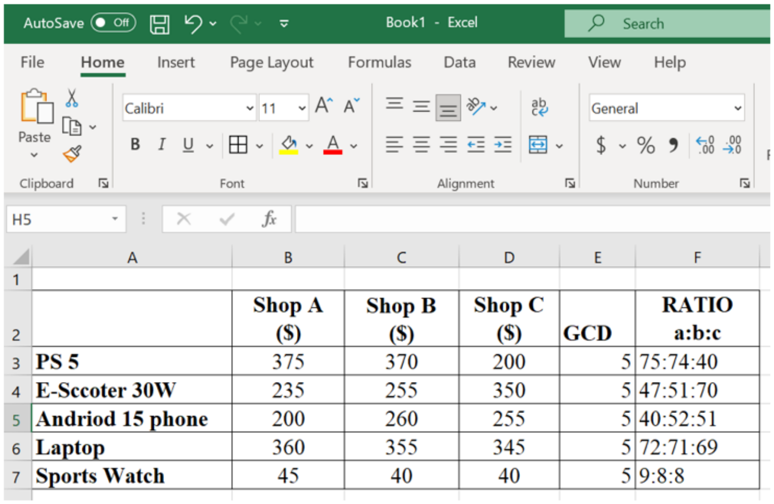
Step 5: Add this formulae in **F3**, then copy same in **F3** to **F7**



=B3/E3 &":"& C3/E3 &":"&D3/E3

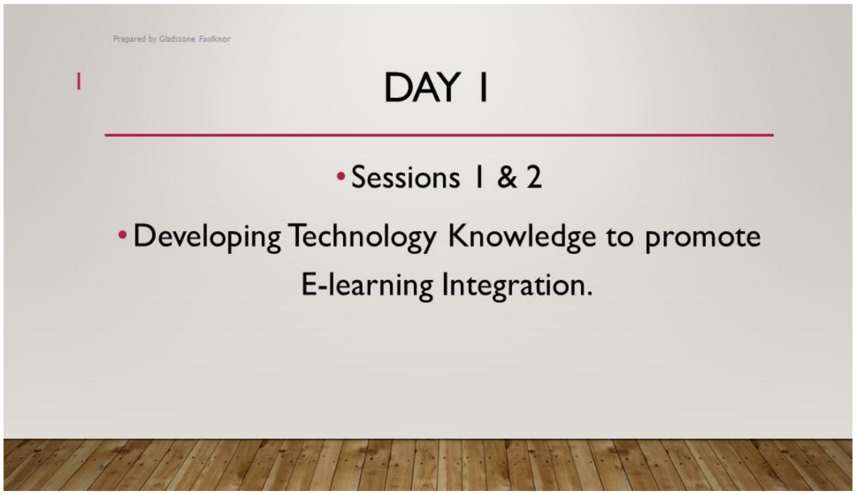
Shop A ($)	Shop B ($)	Shop C ($)	GCD	RATIO a:b:c
375	370	200	5	=B3/E3 &":"& C3/E3 &":"&D3/E3
235	255	350		
200	260	255		

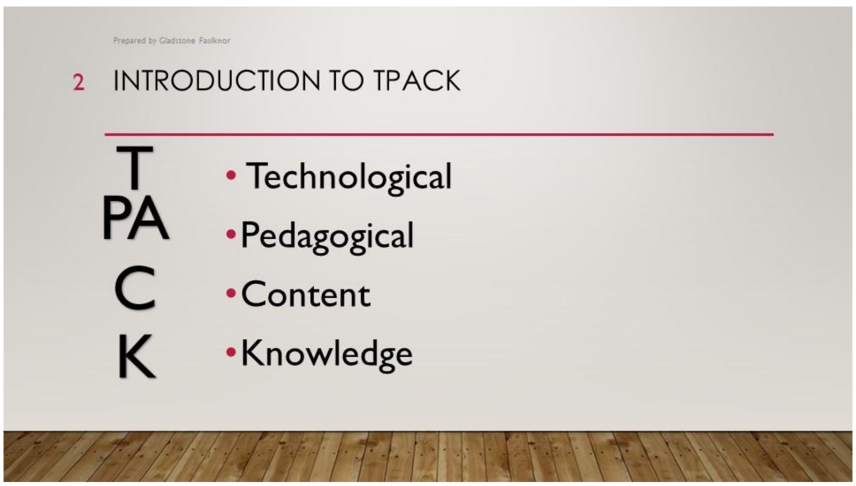
Step 6: You should see something like this

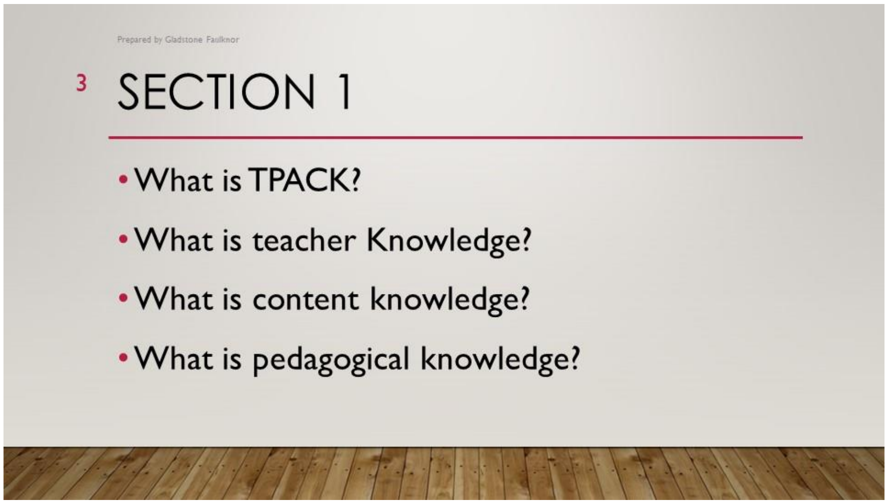


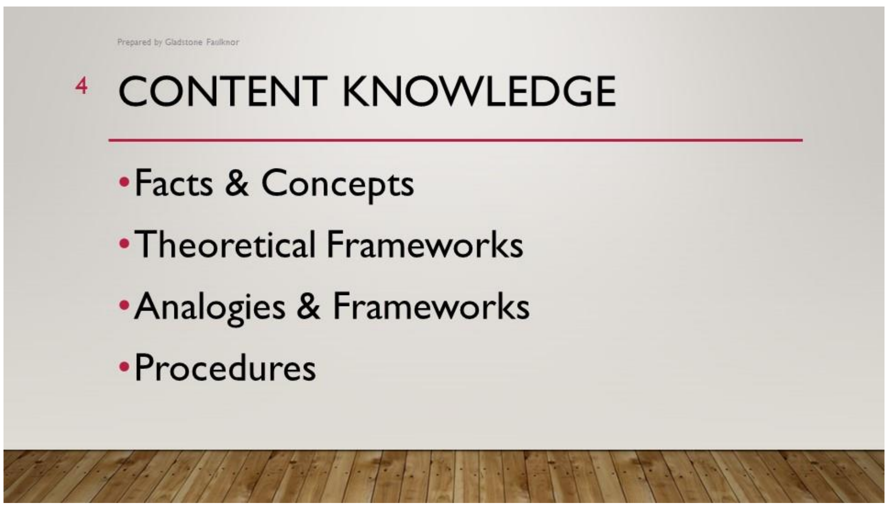
	Shop A ($)	Shop B ($)	Shop C ($)	GCD	RATIO a:b:c
PS 5	375	370	200	5	75:74:40
E-Sccoter 30W	235	255	350	5	47:51:70
Andriod 15 phone	200	260	255	5	40:52:51
Laptop	360	355	345	5	72:71:69
Sports Watch	45	40	40	5	9:8:8

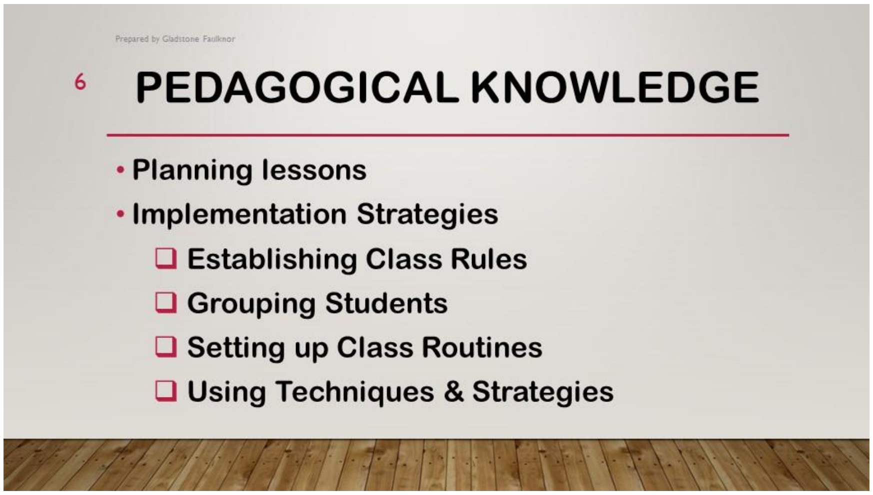
TPACK PowerPoint slides for Presentation

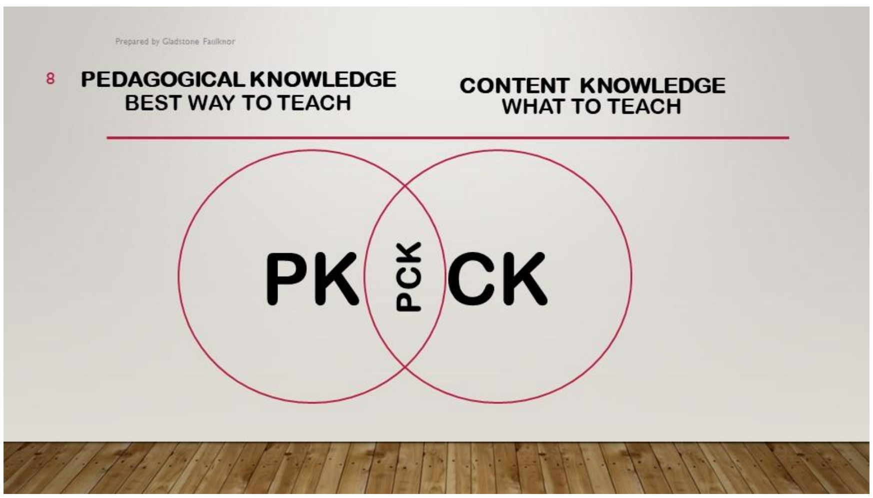


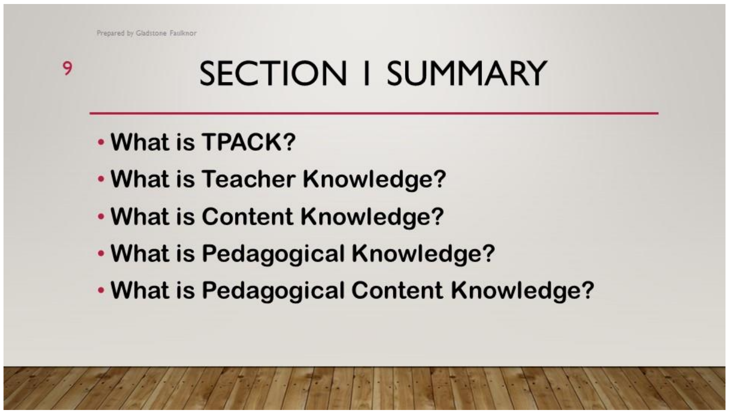


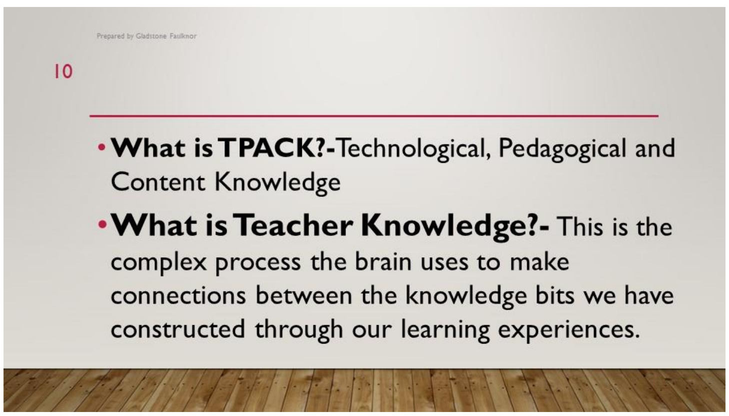

Prepared by Gladstone Faulknor
3
SECTION 1
•What is TPACK?
•What is teacher Knowledge?
•What is content knowledge?
•What is pedagogical knowledge?

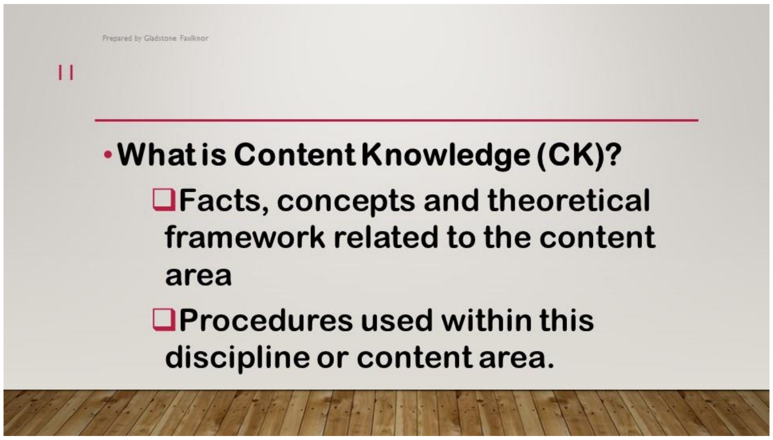

Prepared by Gladstone Faulknor
4
CONTENT KNOWLEDGE
•Facts & Concepts
•Theoretical Frameworks
•Analogies & Frameworks
•Procedures

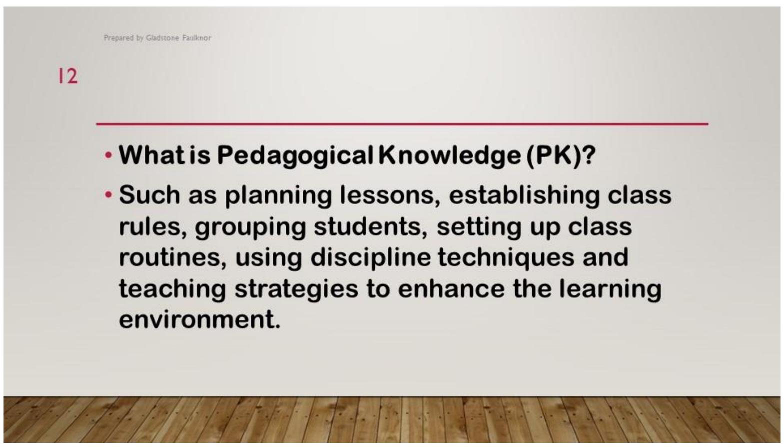

Prepared by Gladstone Faulknor
6
PEDAGOGICAL KNOWLEDGE
• Planning lessons
• Implementation Strategies
Establishing Class Rules
Grouping Students
Setting up Class Routines
Using Techniques & Strategies

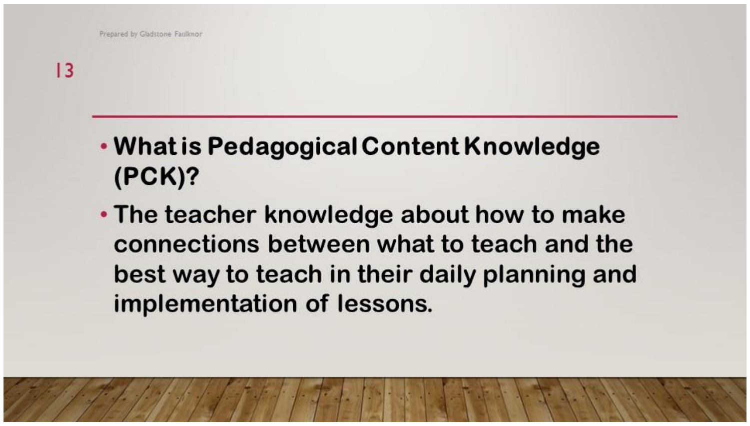

Prepared by Gladstone Faulknor
8
PEDAGOGICAL KNOWLEDGE
BEST WAY TO TEACH
CONTENT KNOWLEDGE
WHAT TO TEACH
PK
PCK
CK

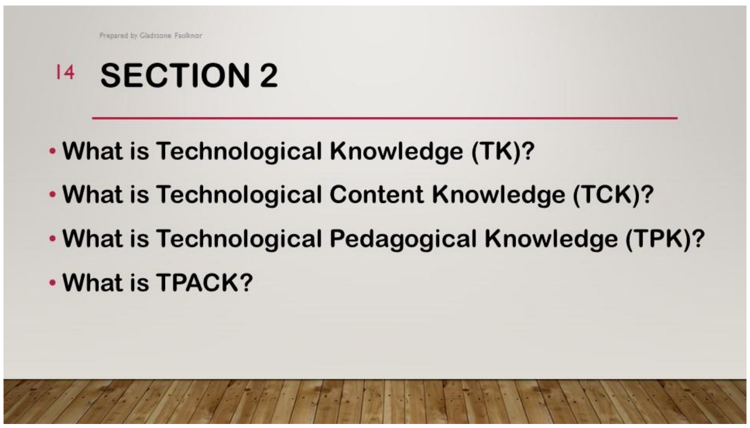

Prepared by Gladstone Faulknor
9
SECTION 1 SUMMARY
• What is TPACK?
• What is Teacher Knowledge?
• What is Content Knowledge?
• What is Pedagogical Knowledge?
• What is Pedagogical Content Knowledge?

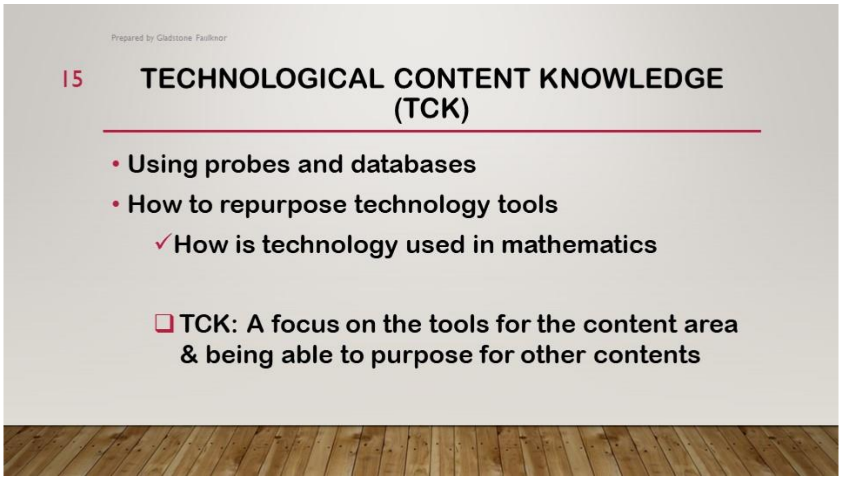

Prepared by Gladstone Faulknor
10
• What is TPACK?-Technological, Pedagogical and Content Knowledge
• What is Teacher Knowledge?- This is the complex process the brain uses to make connections between the knowledge bits we have constructed through our learning experiences.

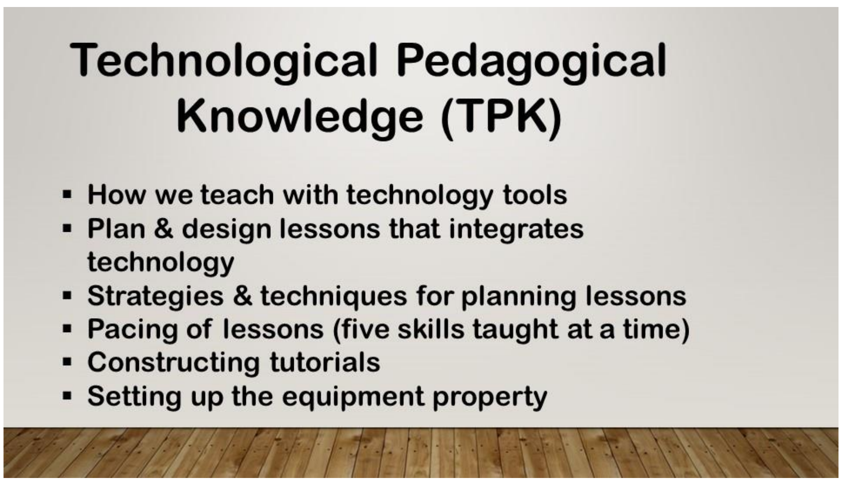

Prepared by Gladstone Faulknor
11
• What is Content Knowledge (CK)?
❑ Facts, concepts and theoretical framework related to the content area
❑ Procedures used within this discipline or content area.

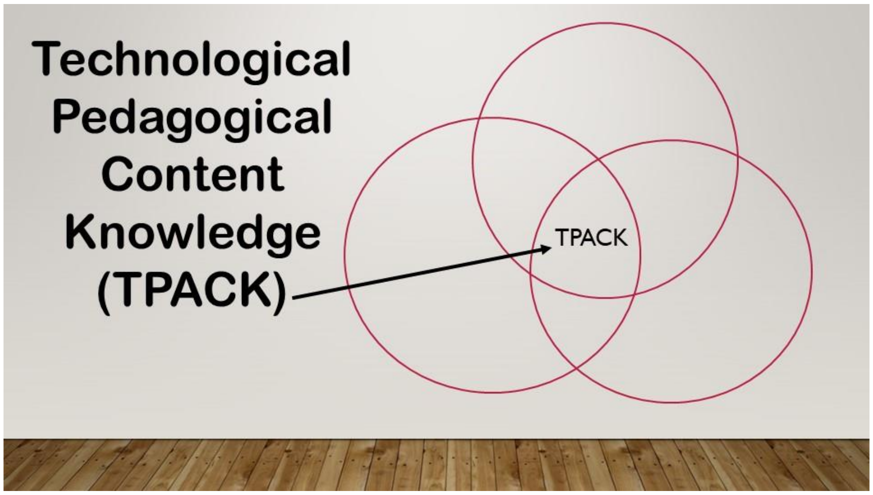

Prepared by Gladstone Faulknor
12
• What is Pedagogical Knowledge (PK)?
• Such as planning lessons, establishing class rules, grouping students, setting up class routines, using discipline techniques and teaching strategies to enhance the learning environment.

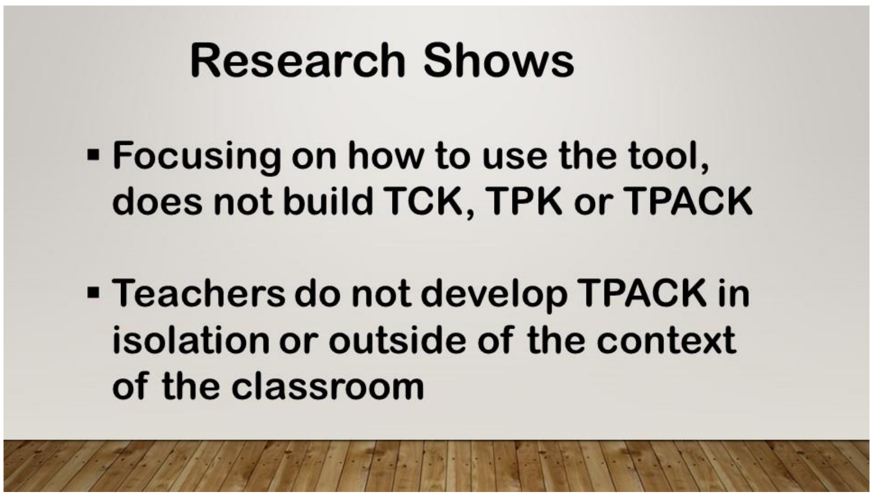

Prepared by Gladstone Faulknor
13
• What is Pedagogical Content Knowledge (PCK)?
• The teacher knowledge about how to make connections between what to teach and the best way to teach in their daily planning and implementation of lessons.

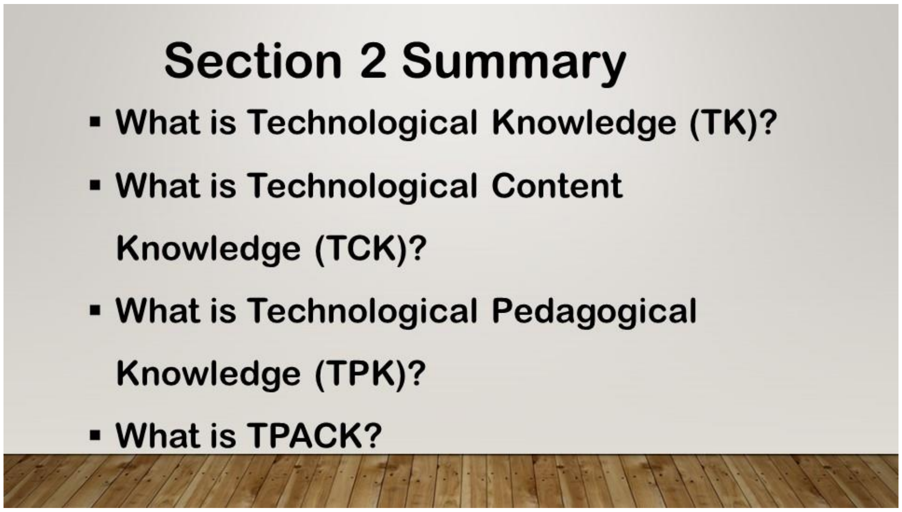

Prepared by Gladstone Faulknor
14
SECTION 2
• What is Technological Knowledge (TK)?
• What is Technological Content Knowledge (TCK)?
• What is Technological Pedagogical Knowledge (TPK)?
• What is TPACK?

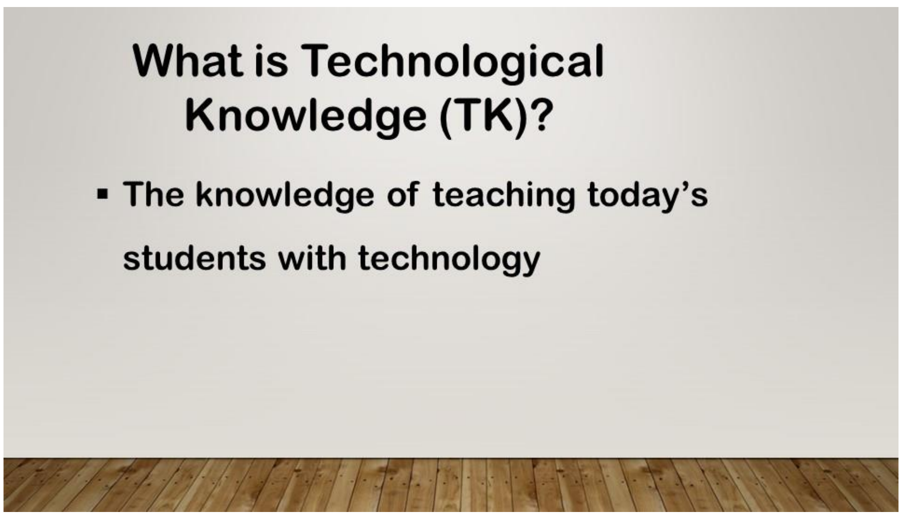

Prepared by Gladstone Faulknor
15
TECHNOLOGICAL CONTENT KNOWLEDGE (TCK)
• Using probes and databases
• How to repurpose technology tools
✓How is technology used in mathematics
❑ TCK: A focus on the tools for the content area & being able to purpose for other contents

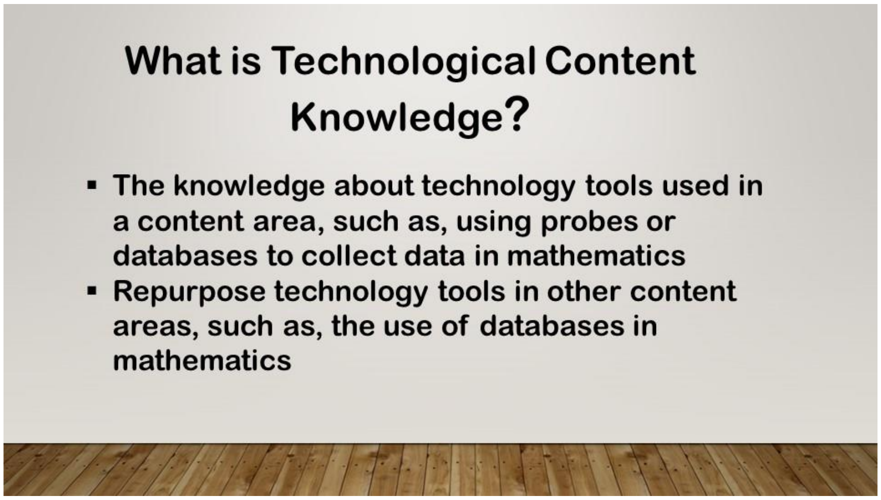

Technological Pedagogical Knowledge (TPK)
▪ How we teach with technology tools
▪ Plan & design lessons that integrates technology
▪ Strategies & techniques for planning lessons
▪ Pacing of lessons (five skills taught at a time)
▪ Constructing tutorials
▪ Setting up the equipment property

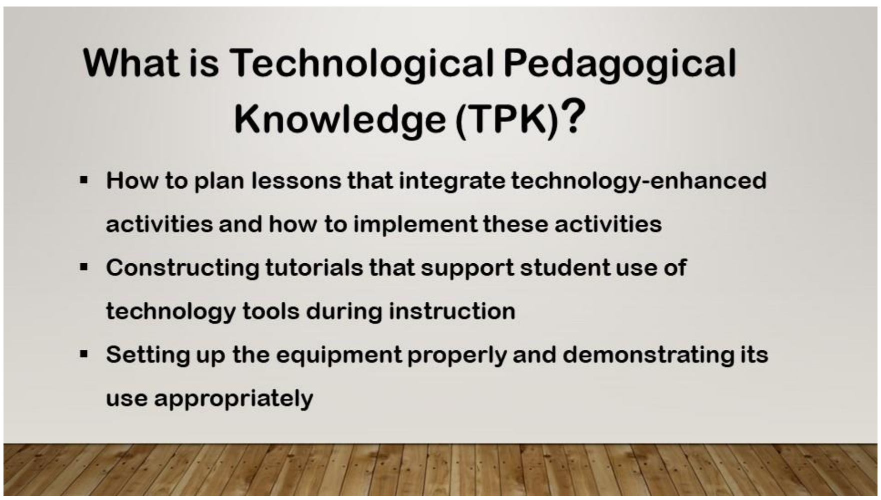

Technological
Pedagogical
Content
Knowledge
(TPACK)
TPACK

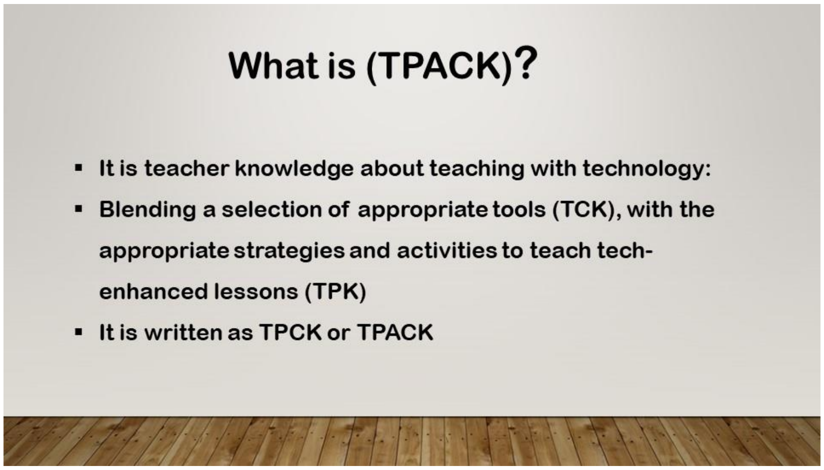

Research Shows
▪ Focusing on how to use the tool, does not build TCK, TPK or TPACK
▪ Teachers do not develop TPACK in isolation or outside of the context of the classroom

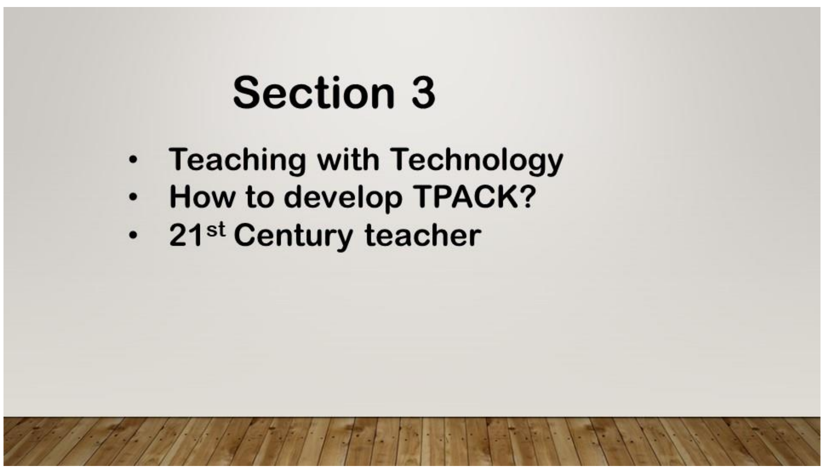

Section 2 Summary
What is Technological Knowledge (TK)?
What is Technological Content Knowledge (TCK)?
What is Technological Pedagogical Knowledge (TPK)?
What is TPACK?

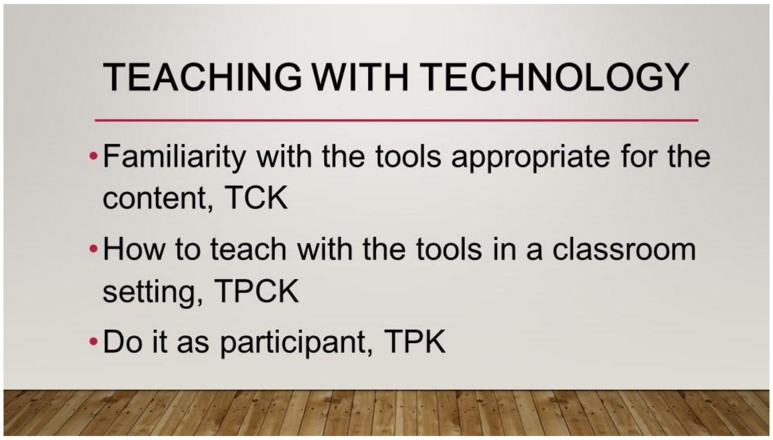

What is Technological Knowledge (TK)?
The knowledge of teaching today's students with technology

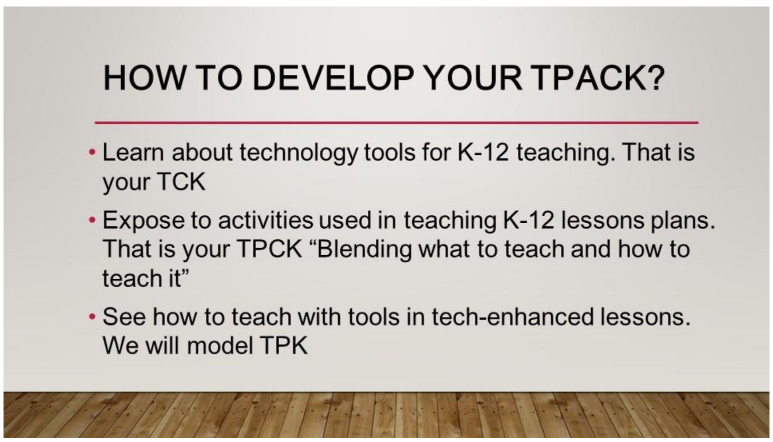

What is Technological Content Knowledge?
The knowledge about technology tools used in a content area, such as, using probes or databases to collect data in mathematics
Repurpose technology tools in other content areas, such as, the use of databases in mathematics

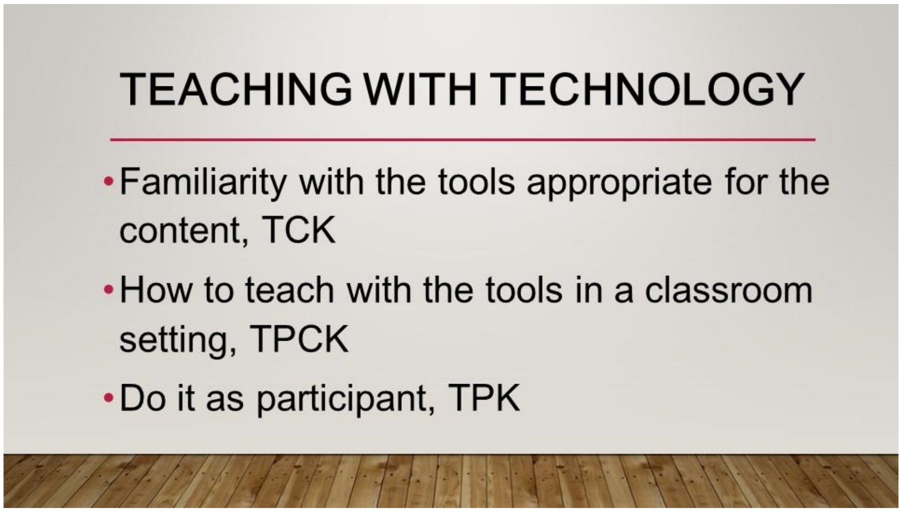

What is Technological Pedagogical Knowledge (TPK)?
How to plan lessons that integrate technology-enhanced activities and how to implement these activities
Constructing tutorials that support student use of technology tools during instruction
Setting up the equipment properly and demonstrating its use appropriately

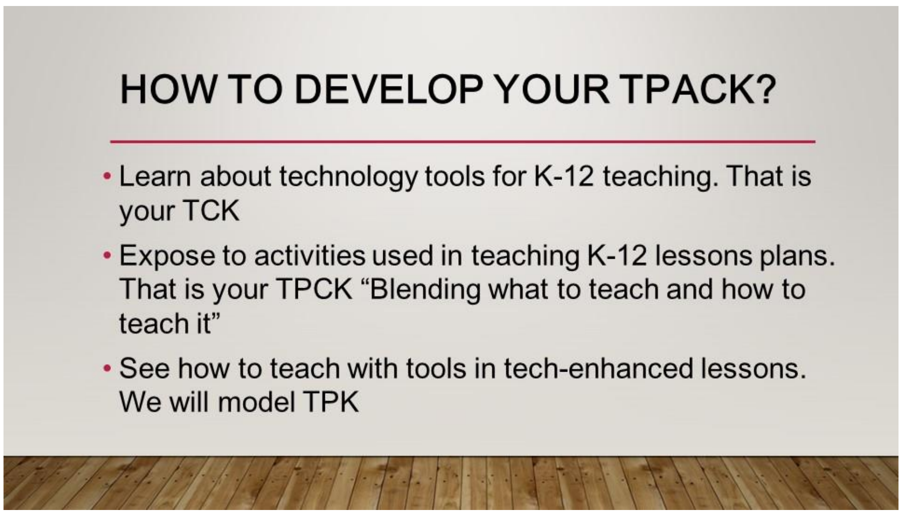

What is (TPACK)?
It is teacher knowledge about teaching with technology:
Blending a selection of appropriate tools (TCK), with the appropriate strategies and activities to teach tech-enhanced lessons (TPK)
It is written as TPCK or TPACK


Section 3
Teaching with Technology
How to develop TPACK?
21st Century teacher


TEACHING WITH TECHNOLOGY
•Familiarity with the tools appropriate for the content, TCK
•How to teach with the tools in a classroom setting, TPCK
•Do it as participant, TPK


HOW TO DEVELOP YOUR TPACK?
• Learn about technology tools for K-12 teaching. That is your TCK
• Expose to activities used in teaching K-12 lessons plans. That is your TPCK “Blending what to teach and how to teach it”
• See how to teach with tools in tech-enhanced lessons. We will model TPK


TEACHING WITH TECHNOLOGY
•Familiarity with the tools appropriate for the content, TCK
•How to teach with the tools in a classroom setting, TPCK
•Do it as participant, TPK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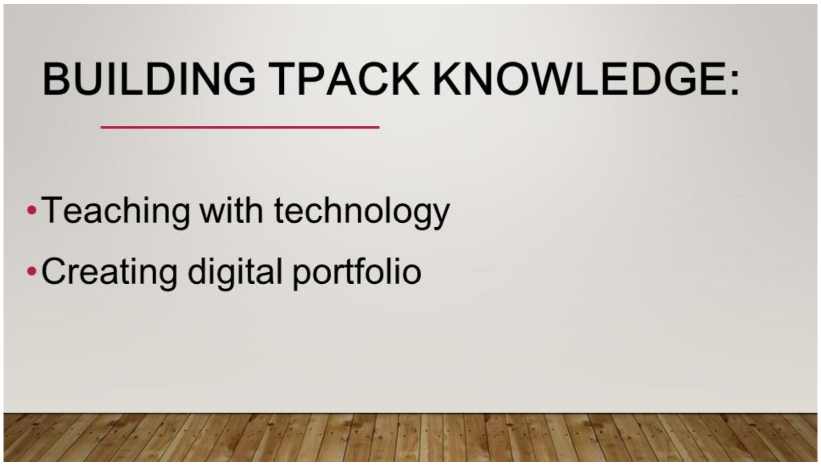
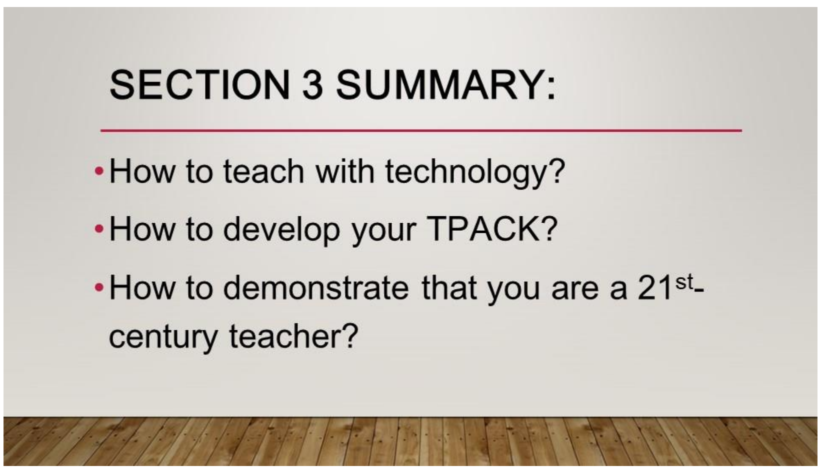
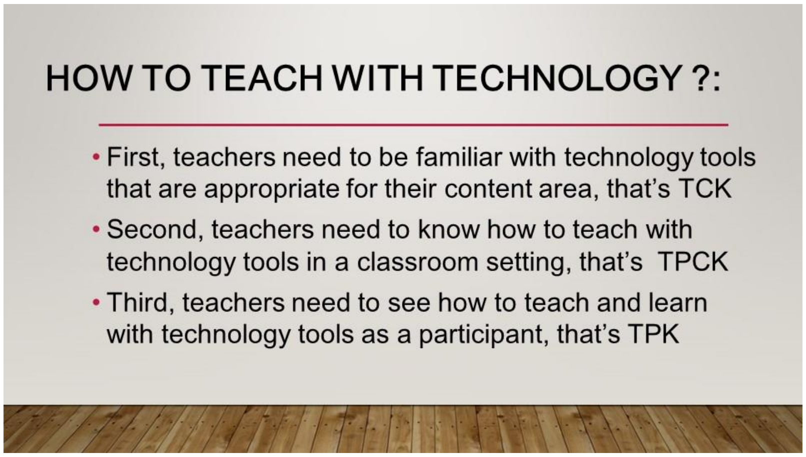
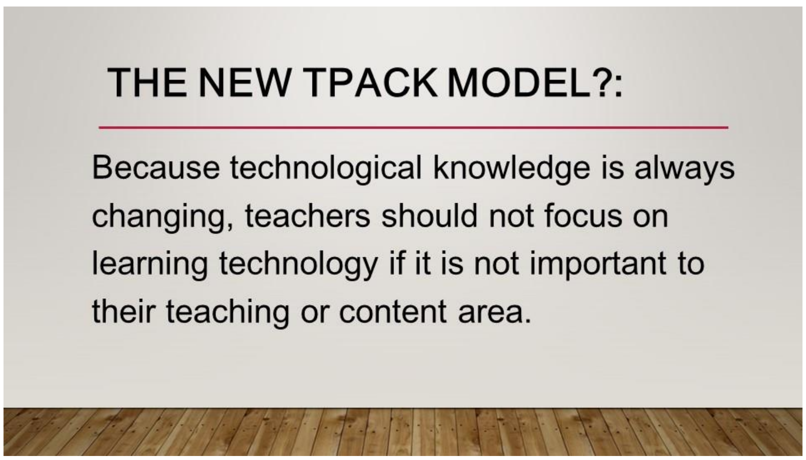
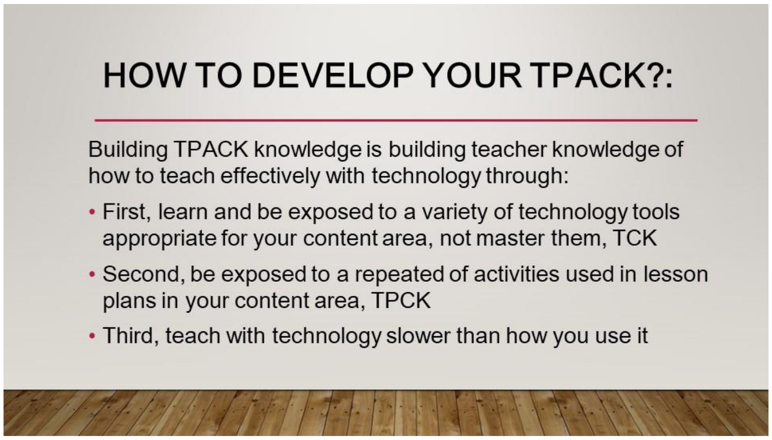
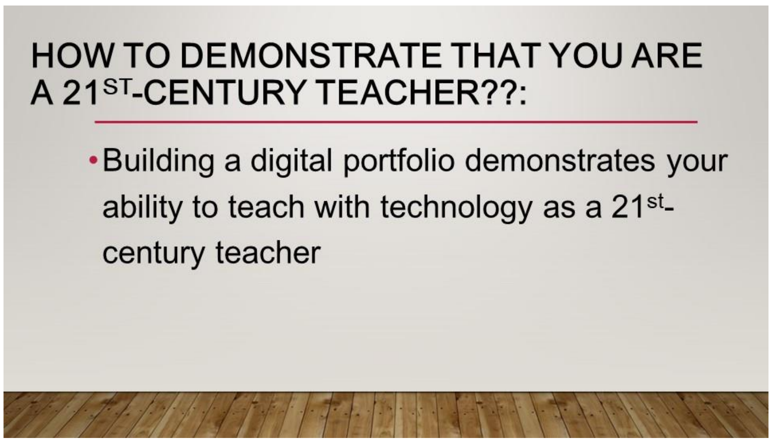

BUILDING TPACK KNOWLEDGE:
•Teaching with technology
•Creating digital portfolio

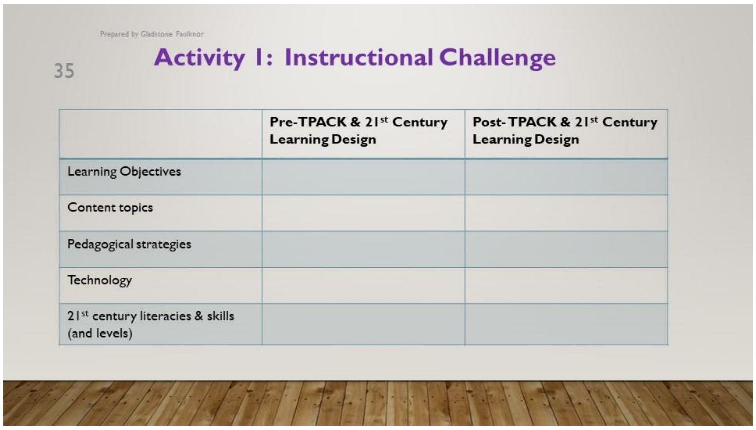

SECTION 3 SUMMARY:
•How to teach with technology?
•How to develop your TPACK?
•How to demonstrate that you are a 21st-century teacher?


HOW TO TEACH WITH TECHNOLOGY ?:
• First, teachers need to be familiar with technology tools that are appropriate for their content area, that's TCK
• Second, teachers need to know how to teach with technology tools in a classroom setting, that's TPCK
• Third, teachers need to see how to teach and learn with technology tools as a participant, that's TPK

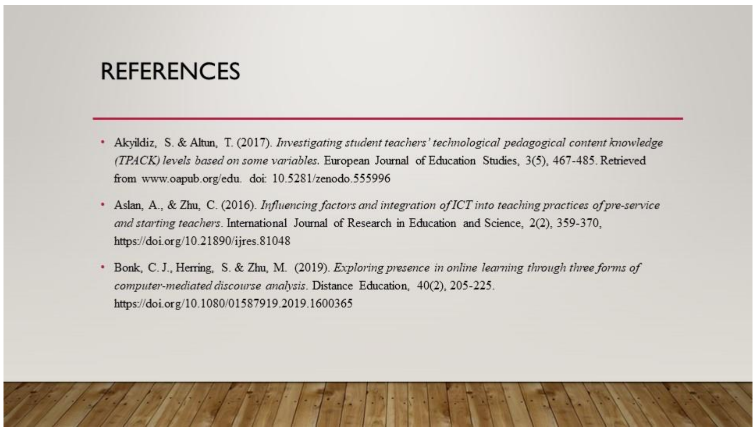

THE NEW TPACK MODEL?:
Because technological knowledge is always changing, teachers should not focus on learning technology if it is not important to their teaching or content area.

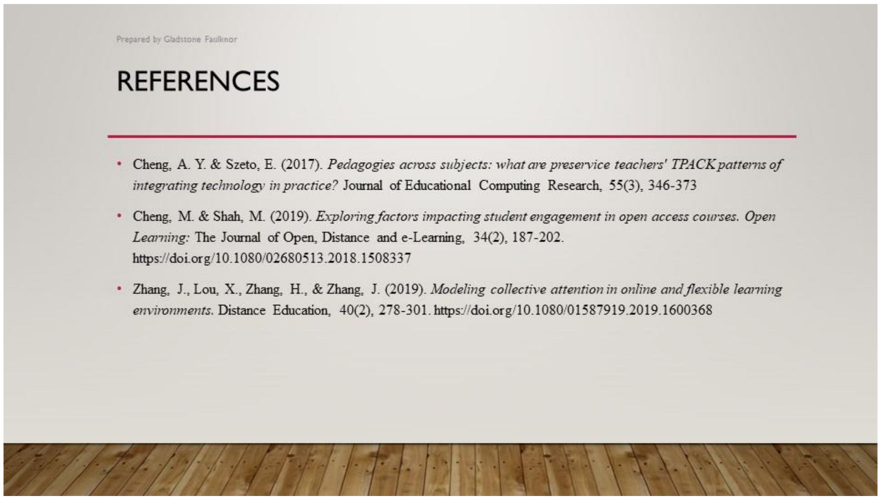

HOW TO DEVELOP YOUR TPACK?:
Building TPACK knowledge is building teacher knowledge of how to teach effectively with technology through:
• First, learn and be exposed to a variety of technology tools appropriate for your content area, not master them, TCK
• Second, be exposed to a repeated of activities used in lesson plans in your content area, TPCK
• Third, teach with technology slower than how you use it


HOW TO DEMONSTRATE THAT YOU ARE A 21ST-CENTURY TEACHER??:
• Building a digital portfolio demonstrates your ability to teach with technology as a 21st-century teacher

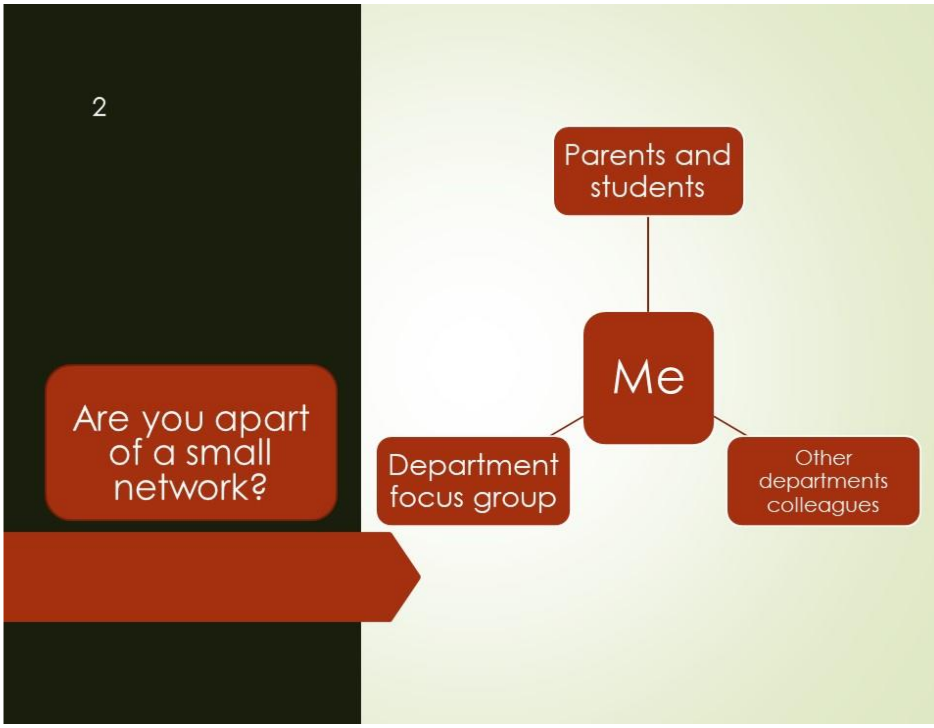


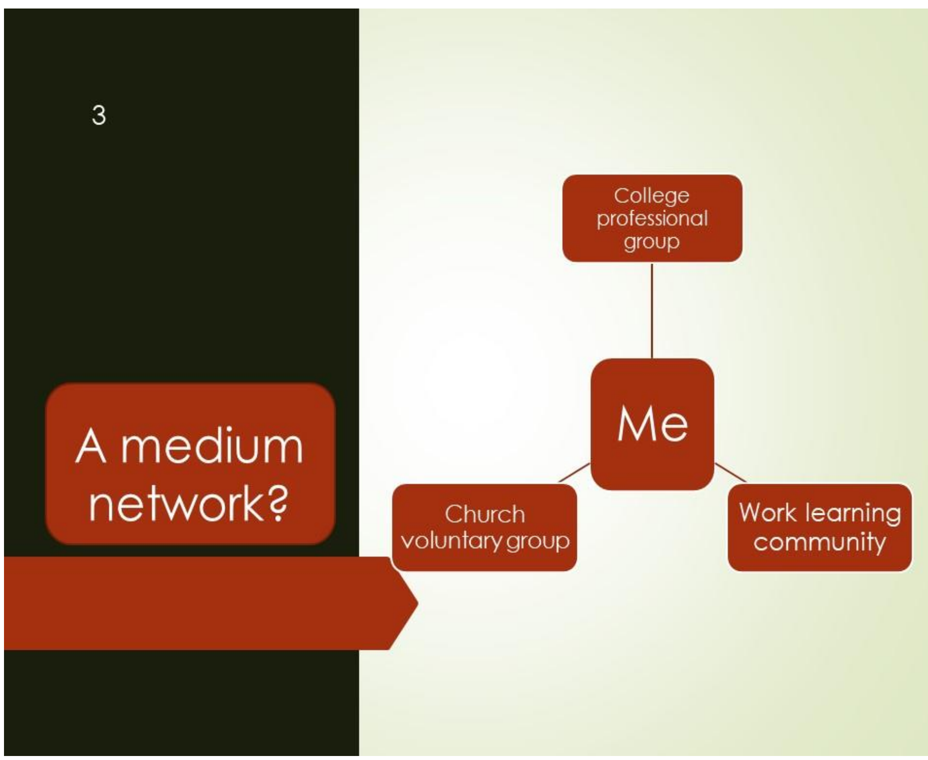
	Pre-TPACK & 21st Century Learning Design	Post- TPACK & 21st Century Learning Design
Learning Objectives		
Content topics		
Pedagogical strategies		
Technology		
21st century literacies & skills (and levels)		

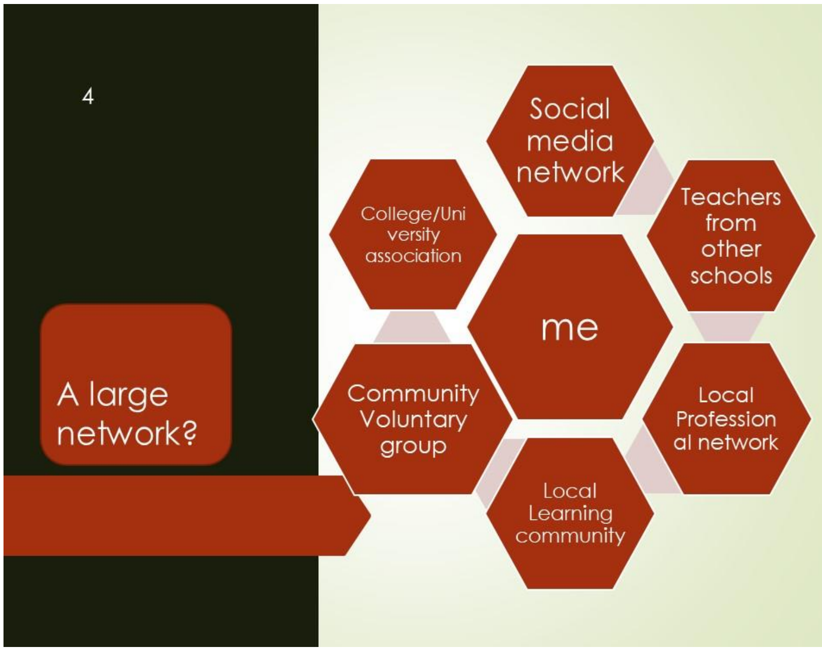




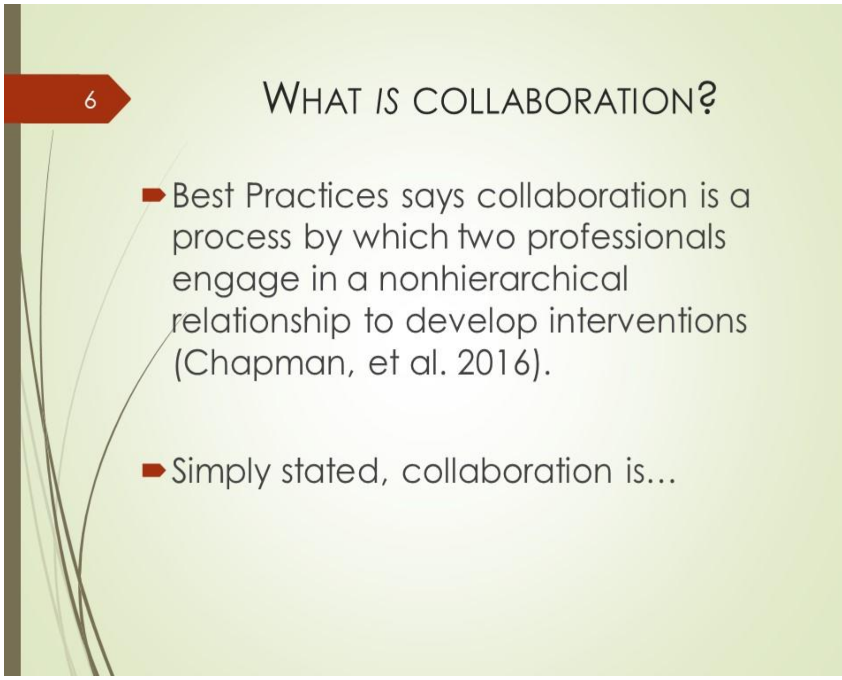
Collaboration through networking PowerPoint slides

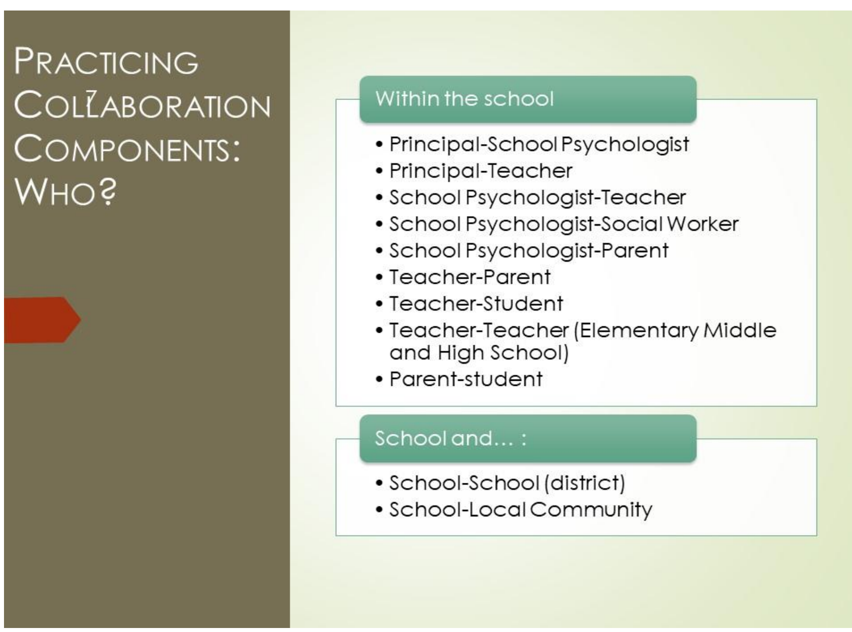

2
Parents and students
Me
Are you apart of a small network?
Department focus group
Other departments colleagues


3
College professional group
Me
A medium network?
Church voluntary group
Work learning community

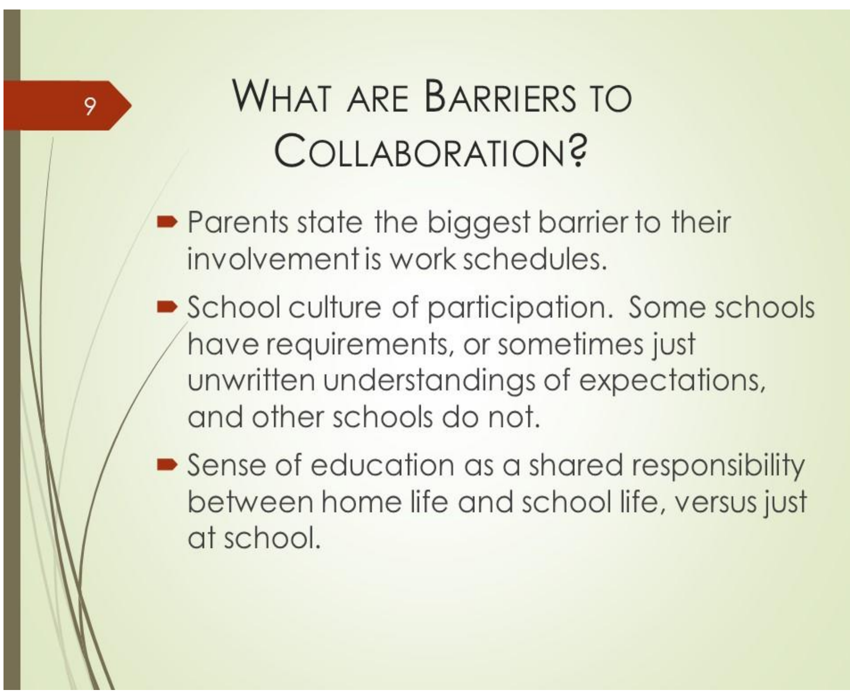

4
A large network?
Social media network
College/University association
Teachers from other schools
me
Community Voluntary group
Local Professional network
Local Learning community

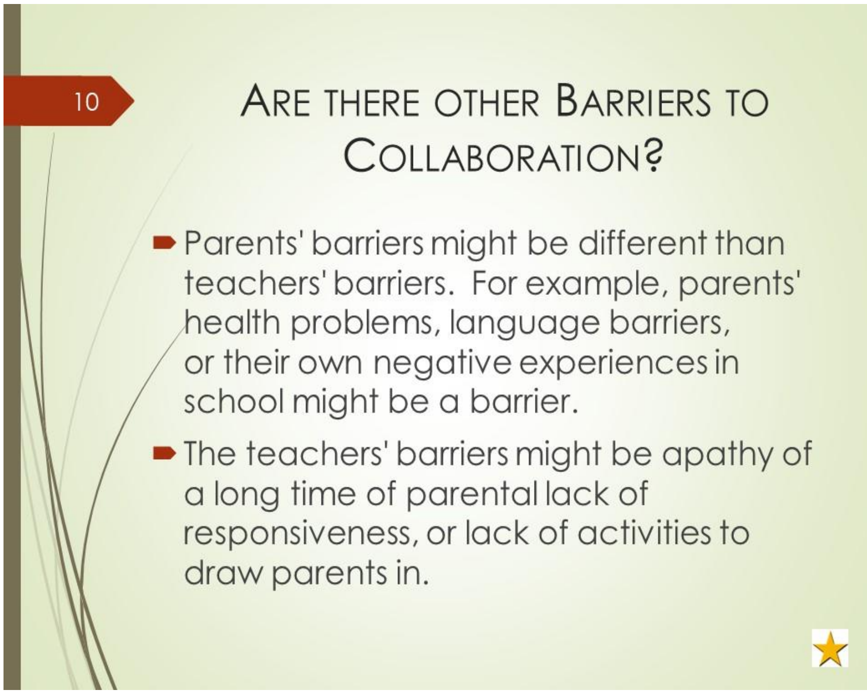

5
THE BUILDING BLOCKS OF COLLABORATION
Components: WHO is involved in collaboration and WHERE it occurs
Barriers: WHAT stands in the way of effective collaboration
Strategies: HOW collaboration occurs
Outcomes: WHY we collaborate


6
WHAT IS COLLABORATION?
Best Practices says collaboration is a process by which two professionals engage in a nonhierarchical relationship to develop interventions (Chapman, et al. 2016).
Simply stated, collaboration is…

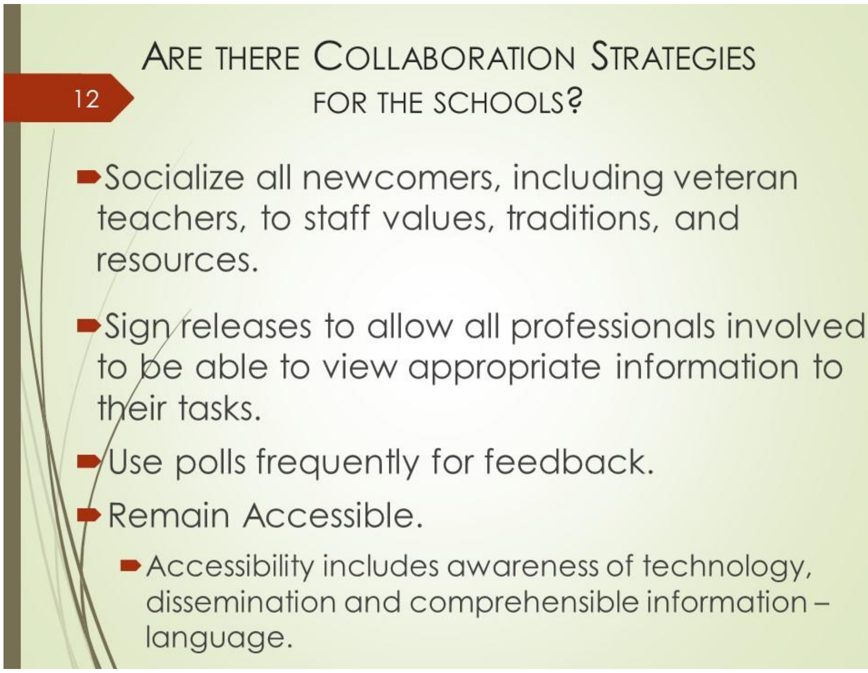

PRACTICING COLLABORATION COMPONENTS: WHO?
Within the school
• Principal-School Psychologist
• Principal-Teacher
• School Psychologist-Teacher
• School Psychologist-Social Worker
• School Psychologist-Parent
• Teacher-Parent
• Teacher-Student
• Teacher-Teacher (Elementary Middle and High School)
• Parent-student
School and… :
• School-School (district)
• School-Local Community

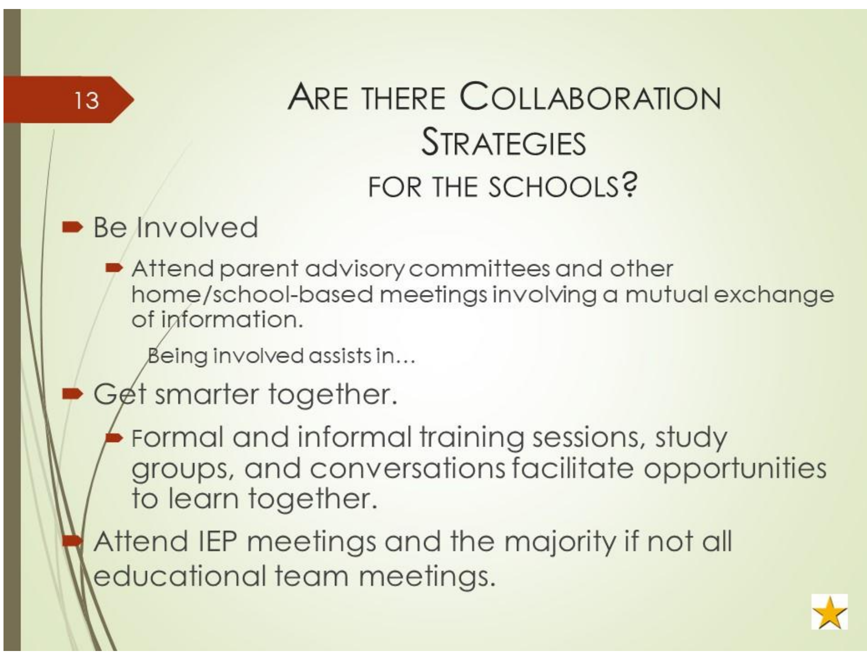

8
Practicing Collaboration Components: The Where
Libraries
Churches
Local education-based organizations including after school programs and non-profit organizations
School
Home
Community


9
What are Barriers to Collaboration?
Parents state the biggest barrier to their involvement is work schedules.
School culture of participation. Some schools have requirements, or sometimes just unwritten understandings of expectations, and other schools do not.
Sense of education as a shared responsibility between home life and school life, versus just at school.

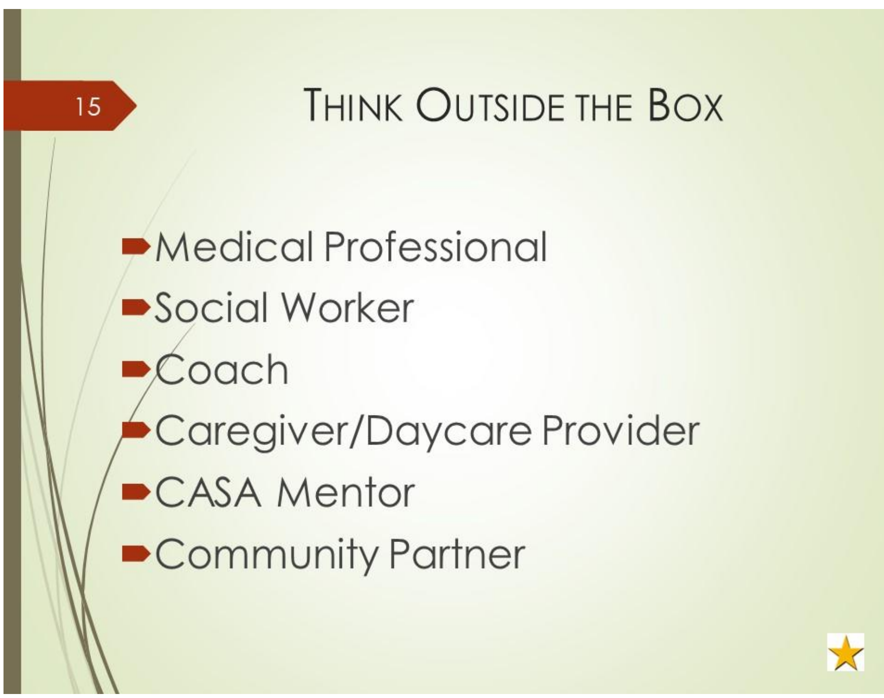

10
ARE THERE OTHER BARRIERS TO COLLABORATION?
Parents' barriers might be different than teachers' barriers. For example, parents' health problems, language barriers, or their own negative experiences in school might be a barrier.
The teachers' barriers might be apathy of a long time of parental lack of responsiveness, or lack of activities to draw parents in.

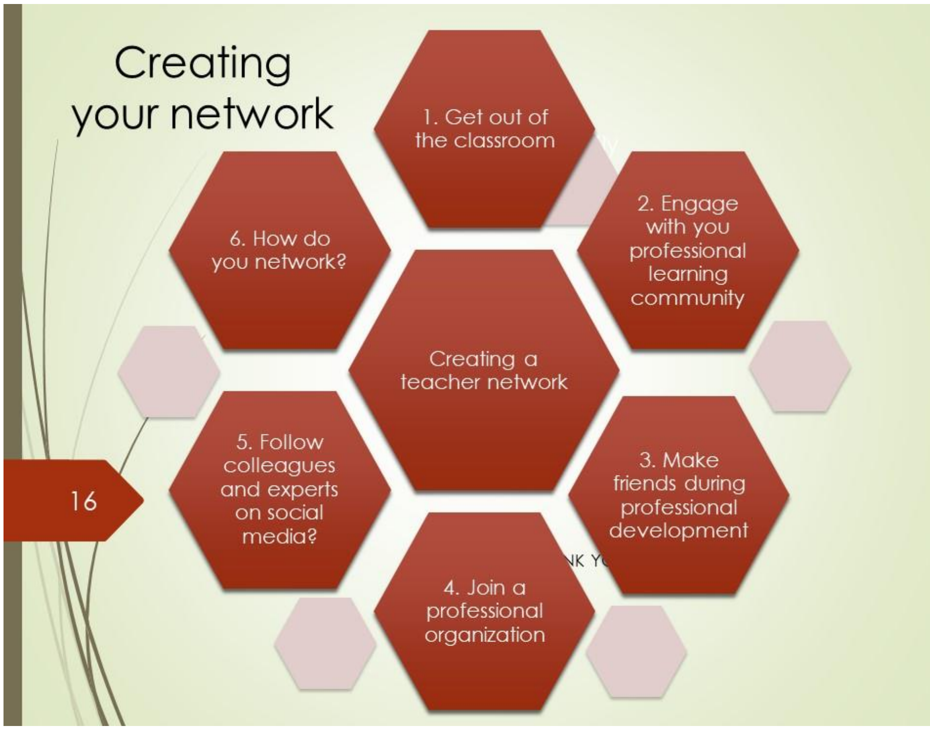

11
ARE THERE COLLABORATION STRATEGIES FOR THE FAMILIES?
Communicate often with teachers to identify and assist student with academic challenges.
Get involved with a parent advisory committee (PAC) or parents' support group.
Develop own knowledge and skills of school systems and resources.
Attend IEP and the majority if not all educational team meetings for child.

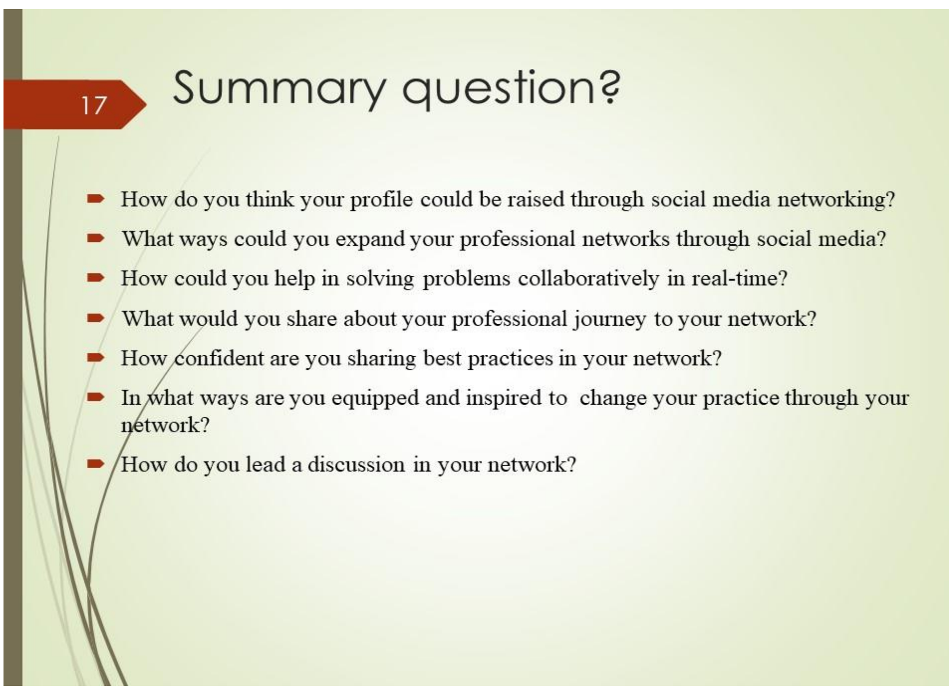

12
ARE THERE COLLABORATION STRATEGIES
FOR THE SCHOOLS?
Socialize all newcomers, including veteran teachers, to staff values, traditions, and resources.
Sign releases to allow all professionals involved to be able to view appropriate information to their tasks.
Use polls frequently for feedback.
Remain Accessible.
Accessibility includes awareness of technology, dissemination and comprehensible information – language.

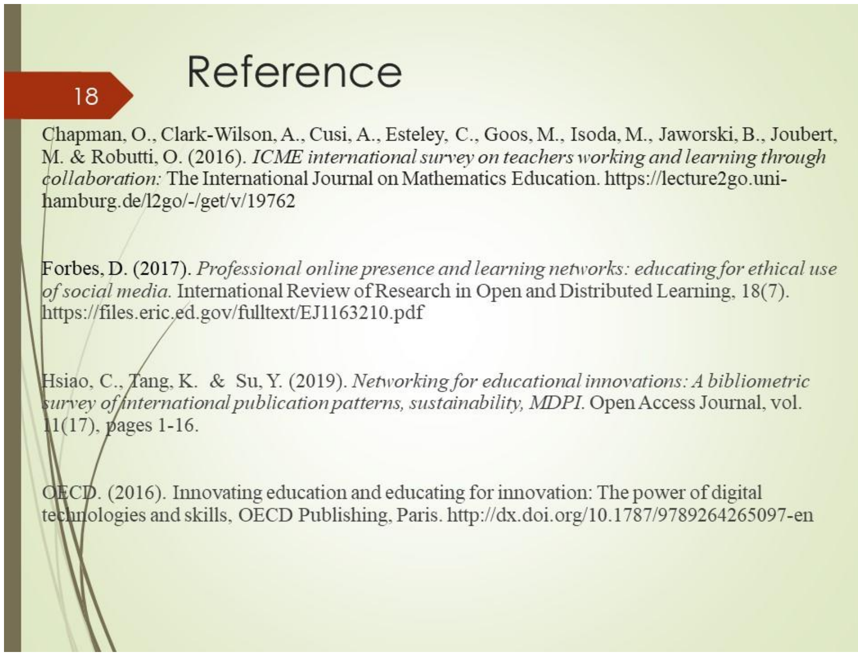

13
ARE THERE COLLABORATION
STRATEGIES
FOR THE SCHOOLS?
Be Involved
Attend parent advisory committees and other home/school-based meetings involving a mutual exchange of information.
Being involved assists in…
Get smarter together.
Formal and informal training sessions, study groups, and conversations facilitate opportunities to learn together.
Attend IEP meetings and the majority if not all educational team meetings.


14
OUTCOMES OF COLLABORATION
BENEFITS & REASONS
Time & Resource Management
Informed Assessment & Decision Making
Buy In/Team building
Systems Level Change
Service Provision & Reinforcement
Reduces Burn-out and Staff Turn Over
Promotes Job Satisfaction
Improves academic outcomes


15
THINK OUTSIDE THE BOX
Medical Professional
Social Worker
Coach
Caregiver/Daycare Provider
CASA Mentor
Community Partner


Creating your network
1. Get out of the classroom
2. Engage with you professional learning community
3. Make friends during professional development
4. Join a professional organization
5. Follow colleagues and experts on social media?
6. How do you network?
Creating a teacher network
16


17
Summary question?
How do you think your profile could be raised through social media networking?
What ways could you expand your professional networks through social media?
How could you help in solving problems collaboratively in real-time?
What would you share about your professional journey to your network?
How confident are you sharing best practices in your network?
In what ways are you equipped and inspired to change your practice through your network?
How do you lead a discussion in your network?


Reference
18
Chapman, O., Clark-Wilson, A., Cusi, A., Esteley, C., Goos, M., Isoda, M., Jaworski, B., Joubert, M. & Robutti, O. (2016). ICME international survey on teachers working and learning through collaboration: The International Journal on Mathematics Education. https://lecture2go.uni-hamburg.de/l2go/-/get/v/19762
Forbes, D. (2017). Professional online presence and learning networks: educating for ethical use of social media. International Review of Research in Open and Distributed Learning, 18(7). https://files.eric.ed.gov/fulltext/EJ1163210.pdf
Hsiao, C., Tang, K. & Su, Y. (2019). Networking for educational innovations: A bibliometric survey of international publication patterns, sustainability, MDPI. Open Access Journal, vol. 11(17), pages 1-16.
OECD. (2016). Innovating education and educating for innovation: The power of digital technologies and skills, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264265097-en

Task 2: Reflection Discussion Questions

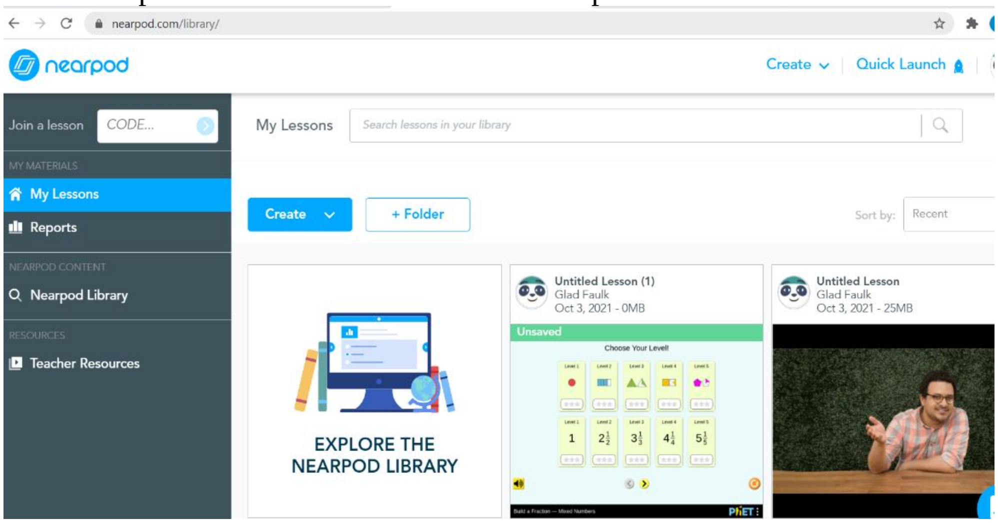
TPACK Reflection

Technological Knowledge Reflection (TK)
• Does the tool do all that I think it can?
• Does the tool do all that I need it to?
• Is the tool simple enough for students to use?
Pedagogical Knowledge Reflection (PK)
• Are the tasks well suited to my outcomes?
• Are the tasks well suited to my learners?
• Are the tasks unclear in any way?
• Does the sequencing of the tasks make sense?
Content Knowledge Reflection (CK)
• Do the students have all of the information they need to complete the task?
• Do the students need any scaffolding I hadn't anticipated?
• Do the students have the necessary content skills needed to complete the task?
Pedagogical Content Knowledge (PCK)
• Are the pedagogical strategies of the tasks appropriate for the types of activities?
• Are there other strategies that I may not use as often (or be as comfortable with), but that might be more appropriate for this task?
Technological Pedagogical Knowledge (TPK)
• Does the tool that I chose fit the type of task that I wanted to do?
• Is there another tool that might be better suited to this type of task?
• Does the tool make sense in terms of the diverse learners in my classroom?
Technology Content Knowledge (TCK)
• Are there ways that the technology can bring new content knowledge to my students in ways that couldn't be done without it?
Technology Pedagogy Content Knowledge (TPCK)
• Is this activity well balanced?
• Does it tend to lean more towards one of the TPACK factors?

Note. *Adopted from enhancing graduate students' reflection in e-portfolios using the TPACK framework* by Baek, Y., Baldwin, S., Ching, Y. H. & Yang, D., 2016, Copyright 2016 by Australasian Journal of Educational Technology.

Using Nearpod

1. Go to nearpod.com and create either a free or paid account.



Reviewing Nearpod Advantages and Disadvantages

Rubric for eLearning Tool Evaluation

This rubric has been designed for instructors and staff as a formative tool to evaluate eLearning tools in higher education. eLearning tools are defined as any digital technology, mediated through the use of a computing device, deliberately selected to support student learning. The rubric supports a multi-dimensional evaluation of functional, technical, and pedagogical aspects of eLearning Tools.

Instructions

Not all rubric criteria are necessarily applicable to all eLearning tools and those using the rubric are encouraged to assess irrelevant criterion as "not applicable". The rubric does not identify a discrete threshold that an eLearning tool needs to cross before a tool should be used; the rubric is a formative tool intended to offer insight into the relative strengths and weaknesses of an eLearning Tool, as evaluated against a set of criteria.

Category	Criteria	Works Well	Minor Concerns	Serious Concerns	Not applicable
Functionality	Scale	The tool can be scaled to accommodate any size class with the flexibility to create smaller sub-groups or communities of practice	The tool can scaled to accommodate any size class but lacks flexibility to create smaller sub-groups or communities of practice	The tool is restrictive to a limited number of users and cannot be scaled	
	Ease of Use	The tool has a user-friendly interface and it is easy for instructors and students to become skillful with in a personalized and intuitive manner.	The tool has an interface that may be confusing to either instructor or learner; there is limited opportunity for personalization.	The interface is not user-friendly for either the instructor or learner; it is cumbersome, unintuitive, rigid, and inflexible.	
	Tech Support / Help Availability	Campus-based technical support and /or help documentation is readily available and aids users in troubleshooting tasks or solving problems experienced; or, the tool provider offers a robust support platform	Technical support and help documentation is available but limited, incomplete, or not user-friendly	Technological support and help documentation is not available	

	Hypermediality	The tool allows users to communicate through different channels (audio, visual, textual) and allows for non-sequential, flexible/adaptive engagement with material	The tool allows users to communicate through different channels (audio, visual, textual) but is limited in its ability to provide non-sequential, flexible/adaptive engagement with material	The tool is restrictive in terms of the communication channels employed (audio, visual, textual) and presents information sequentially in a rigid, inflexible format	
Accessibility	Accessibility standards	The tool meets accessibility guidelines (e.g. local accessibility legislation and/or W3C WCAG 2.0 standards)	The tool has some limited capacity to meet accessibility guidelines	The tool fails meet accessibility guidelines or no information of compliance has been made available for the tool	
	User-focused participation	The tool is designed to address the needs of diverse users, their various literacies, and capabilities, thereby widening opportunities for participation in learning	The tool has some limited capacity to address the needs of diverse users, their various literacies, and capabilities	The tool is restrictive in meeting the diversity of needs reflective in the student body. The tool likely restricts some learners from fully participating.	
	Required Equipment	Proper use of the tool does not require equipment beyond what is typically available to instructors and students (computer with built-in speakers and microphone, internet connection, etc.)	Proper use of the tool requires specialized equipment (e.g. unique device) that likely requires purchase at a low cost	Proper use of the tool requires specialized equipment requiring moderate to significant financial investment	

	Cost of Use	All aspects of the tool can be used free of charge.	Limited aspects of the tool can be used for free with other elements requiring payment of a fee, membership, or subscription.	Use of the tool requires a fee, membership, or subscription Use of the tool requires a purchase that is likely to pose a financial burden on students (exceeding $50 for a single half term course)	
Technical	Integration/ Embedding within a Learning Management System (LMS)	The tool can be embedded (as an object via HTML code) or fully integrated (e.g. LTI-compliant tools) into an LMS while maintaining full functionality of the tool.	The tool can be embedded within an LMS, perhaps with with limited functionality, but can not be fully integrated.	The tool can only be accessed in an LMS through a hyperlink or static representations of the tool (e.g file export), rather than a functional version of the tool itself	
	Desktop / Laptop Operating Systems	Users can effectively utilize the tool with any standard, up-to-date operating system.	Users may encounter limited or altered functionality depending on the up-to-date operating system being used	Users are limited to using the tool with one specific, up-to-date operating system.	
	Browser	Users can effectively utilize the tool with any standard, up-to-date browser	Users may encounter limited or altered functionality depending on the up-to-date browser being used	Users are limited to using the tool through one specific browser	

	Additional Downloads	Users do not need to download additional software or browser extensions.	The tool uses a browser extension or software that requires a download and / or user permission to run.	The tool requires a past or version of a browser extension or software.	
Mobile Design	Access	The tool can be accessed, either through the download of an app or via a mobile browser, regardless of the mobile operating system and device. Design of the mobile tool fully takes into consideration the constraints of a smaller-sized screen.	The tool offers an app, but only for a limited set of mobile operating systems. Tool is not accessible through a mobile browser. Design of the mobile tool constrained by the limitations of the mobile device.	Access to the tool is limited or absent on a mobile device.	
	Functionality	There is little to no functional difference between the mobile and the desktop version, regardless of the device used to access it. No difference in functionality between apps designed for different mobile operating systems.	Core features of the main tool are functional on the mobile app but advanced features are limited. Some difference in functionality between apps designed for different mobile operating systems, but has limited impact on learners' use of the tool.	The mobile app functions poorly such that core features are not reliable or non-existent. Significant difference in functionality depending on the mobile device's operating system used to access the tool.	
	Offline Access	Offers an offline mode: Core features of the tool can be accessed and utilized even when offline, maintaining functionality and content.	Offers a kind of offline mode, where the tool can be used offline but core functionality and content are affected.	The mobile platform cannot be used in any capacity offline.	

Privacy, Data Protection, and Rights	Sign Up/ Sign In	Use of the tool does not require the creation of an external account or additional login, such that no personal user information is collected and shared.	Either instructors are the only users required to provide personal information to set up an account; or the tool has been vetted through appropriate channels to ensure strict adherence to local, institutional, or personal policies/standards for protecting the collection and use of student personal data by a third party group.	All users (instructors and learners) must provide personal information to a third party in creating an account and there is some question or concern of the adherence to local, institutional, or personal policies/standards for protecting the collection and use of such data by the third party group.	
	Data Privacy and Ownership	Users maintain ownership and copyright of their intellectual property/data; the user can keep data private and decide if / how data is to be shared	Users maintain ownership and copyright of their intellectual property/data; data is shared publically and cannot be made private	Users forfeit ownership and copyright of data; data is shared publically and cannot be made private, or no details provided.	
	Archiving, Saving, and Exporting Data	Users can archive, save, or import and export content or activity data in a variety of formats	There are limitations to archiving, saving, or importing/exporting content or activity data	Content and activity data cannot be archived, saved, or imported exported	
Social Presence	Collaboration	The tool has the capacity to support a community of learning through both asynchronous and synchronous opportunities for communication, interactivity, and transfer of meaning between users	The tool has the capacity to support a community of learning through asynchronous but not synchronous opportunities for communication, interactivity, and transfer of meaning between users	Communication, interactivity, and transfer of meaning between users is not supported or significantly limited	

	User Accountability	Instructors can control learner anonymity; the tool provides technical solutions for holding learners accountable for their actions	Instructors cannot control learner anonymity but the tool provides some solution for holding learners accountable for their actions	Instructors cannot control learner anonymity and there is no technical solution for holding users accountable to their actions	
	Diffusion	The tool is widely known and popular, it's likely that most learners are familiar with the tool and have basic technical competence with it	Learners' familiarity with the tool is likely mixed, some will lack basic technical competence with its functions	The tool is not well known/foreign, it is likely that learners are not familiar with the tool and lack basic technical competence with its functions	
Teaching Presence	Facilitation	The tool has easy-to-use features that would significantly improve an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback	The tool has limited functionality to effectively support an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback	The tool has not been designed to support an instructor's an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback	
	Customization	Tool is adaptable to its environment: easily customized to suit the classroom context and targeted learning outcomes	Limited aspects of the tool can be customized to suit the classroom context and learning outcomes	The tool cannot be customized	
	Learning Analytics	Instructor can monitor learners' performance on a variety of responsive measures. These measures can be accessed through a user-friendly dashboard	Instructor can monitor learners' performance on limited measures; or data is not presented in a format that is easily interpreted	The tool does not support the collection of learning analytics	
Cognitive Presence	Enhancement of Cognitive Task(s)	The tool enhances engagement in targeted cognitive task(s) that were once overly complex or inconceivable through other means	The tool enables functional improvement to engagement in the targeted cognitive task(s)	The tool acts as a direct tool substitute with no functional change to engagement in the targeted cognitive task(s)	
	Higher Order Thinking	Use of the tool easily facilitates learners to exercise higher order thinking skills (given consideration to design, facilitation, and direction from instructor)	The tool may engage learners in higher order thinking skills (given significant consideration to design, facilitation, and direction from instructor)	The tool likely does not engage learners in higher order thinking skills (despite significant consideration to design, facilitation, and direction from instructor)	
	Metacognitive Engagement	Through the tool, learners can regularly receive formative feedback on learning (i.e. they can track their performance, monitor their improvement, test their knowledge)	Opportunities for receiving formative feedback on learning are available, but infrequent or limited (i.e. poor opportunities for tracking performance, monitoring improvement, testing knowledge on a regular basis)	There are no opportunities for formative feedback on learning (i.e. lacking opportunities for tracking performance, monitoring improvement, testing knowledge on a regular basis)	

Note. Adopted from *a rubric for evaluating E-Learning tools in higher education* by Anstey, L. & Watson, G. P. L., 2018, copyright 2018, Memorial University of Newfoundland.

Day 1, 2 and 3 Reference Resources

Google Classroom (https://classroom.google.com)	Microsoft Office (Word, Excel, PowerPoint)	Khan Academy (www.khanacademy.org)
Matrix (https://matrixcalc.org/en/)	Math Playground (www.mathpayground.com)	KaHoot (https://getkahoot.com)
SmartBoard (https://education.smarttech.com)	Nearpod (https://nearpod.com)	Padlet (https://padlet.com)
Microsoft Forms (https://forms.office.com/)	Blended Learning (https://www.youtube.com/watch?v=WyMw-xEvDIc)	CSEC mathematics questions (SR-CSECSocstudg-MayJune2014.pdf (cxc.org))

Blended learning presentation

Note. *Adopted from Transformation in e-learning: an overview of blended learning* by Gardner, D.2017, copyright YouTube 2017, Walden University.

CSEC Mathematics questions: Spot the Error

VECTORS AND MATRICES

11. (a) The matrix M is defined as

$$M = \begin{pmatrix} 7 & 2 \\ p & -1 \end{pmatrix}$$

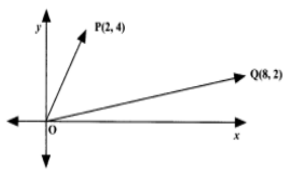
Determine the value of p for which the matrix M does NOT have an inverse. **(2 marks)**

(b) Express the equations

$4x - 2y = 0$
$2x + 3y = 4$

in the form $AX = B$, where A, X and B are matrices. **(2 marks)**

(c) In the diagram below, the coordinates of P and Q are (2, 4) and (8, 2) respectively. The line segment joining the origin (0, 0) to the point P may be written as $\overrightarrow{OP}$.



(i) What term is used to describe $\overrightarrow{OP}$? **(2 marks)**

(ii) Write EACH of the following in the form : $\begin{pmatrix} a \\ b \end{pmatrix}$

a) $\overrightarrow{OP}$ **(1 mark)**

b) $\overrightarrow{OQ}$ **(1 mark)**

c) $\overrightarrow{PQ}$ **(2 marks)**

(iii) Given that $\overrightarrow{OP} = \overrightarrow{RQ}$, determine the coordinates of the point, R. **(3 marks)**

(iv) State the type of quadrilateral formed by $PQRO$. **Justify your answer.** **(2 marks)**

Total 15 marks

This question tested candidates' ability to

- solve for one unknown in a singular matrix
- use the matrix method to solve an equation with two unknowns
- recognize the position vector of a point in the plane
- write the coordinates of points in the plane as position vectors
- use vector geometry to determine the resultant of two or more vectors
- use the properties of equal vectors to solve problems in geometry.

11. .vectors and matrices

$$M = \begin{pmatrix} 7 & 2 \\ p & -1 \end{pmatrix},$$

a. $|M| = 0 \rightarrow -7 - 2p = 0$

$p = -\frac{7}{2}$

b. $\begin{pmatrix} 4 & -2 \\ 2 & 3 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 0 \\ 4 \end{pmatrix}$

c. ..

i. OP is a position vector

ii. ..

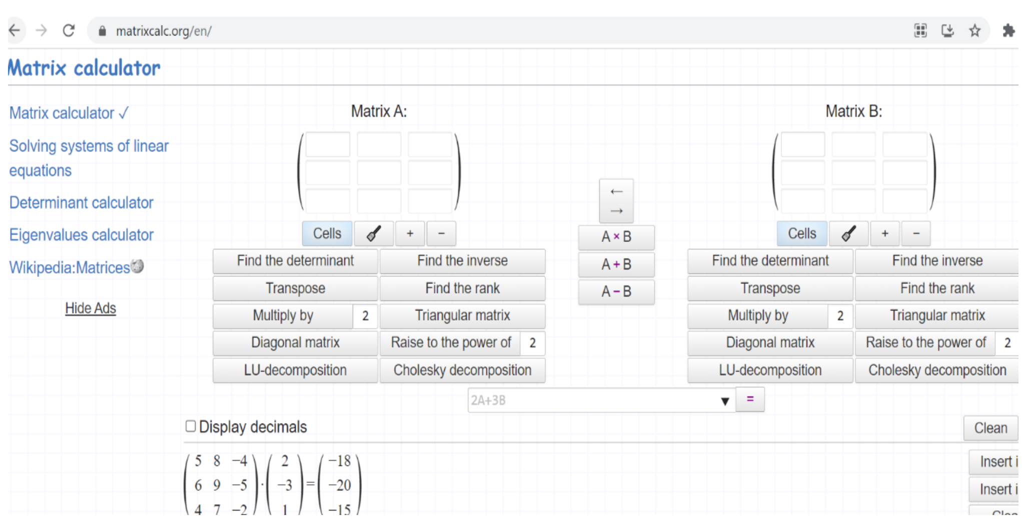
a. $OP = \begin{pmatrix} 2 \\ 4 \end{pmatrix}$

b. $OQ = \begin{pmatrix} 8 \\ 2 \end{pmatrix}$

$PQ = PO + OQ$

c. $PQ = \begin{pmatrix} 6 \\ -2 \end{pmatrix}$

Solving matrices using online software



Day 3 Professional development evaluation

The question was attempted by 37 per cent of the candidates, less than 1 per cent of whom earned the maximum available mark. The mean mark was 3.90 out of 15.

Candidates performed unsatisfactorily on this question. Most candidates seemed unaware of the condition under which the matrix would not have an inverse, that is, when $|M| = 0$. A few candidates were able to express the simultaneous equations in the required form and some continued to attempt to find a solution although this was not required.

In Part (c), candidates generally wrote the position vectors as required. However, challenges were experienced in determining the coordinates of the point R and identifying the type of quadrilateral.

Solutions

(a) $p = \frac{-7}{2}$

(b) $\begin{pmatrix} 4 & -2 \\ 2 & 3 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 0 \\ 4 \end{pmatrix}$

(c) (i) $\overrightarrow{OP}$ **is the position vector of the point** P

(ii) a) $\overrightarrow{OP} = \begin{pmatrix} 2 \\ 4 \end{pmatrix}$; b) $\overrightarrow{OQ} = \begin{pmatrix} 8 \\ 2 \end{pmatrix}$; c) $\overrightarrow{PQ} = \begin{pmatrix} 6 \\ -2 \end{pmatrix}$

(iii) $R\,(6, -2)$

(iv) $PQRO$ **is a parallelogram. It is a quadrilateral with a pair of opposite sides equal and parallel.**

Recommendations

Teachers should encourage students to utilize diagrams to add clarity to their responses when solving problems on Vector Geometry. They should reinforce the concept that a resultant vector can be derived from the sum or difference of two or more position vectors. They should provide students with opportunity to develop the art of identifying the type of quadrilateral formed from a system of vectors in which there are equal or parallel combinations. They should provide students with more practice in writing the matrix equation corresponding to a pair of simultaneous linear equations.

Please complete the following evaluation form based on today's professional development session. Thank you in advance for your time.

Participants Name:	Session Name:	Group Leader:	Date:
___________________	___________________	___________________	___________________

I am satisfied with today's session

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Handouts were engaging and useful

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Time in the session was sufficient to allow learning & practicing new concepts.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

The session was well planned and interactive.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

The session leader was effective.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

The atmosphere was enthusiastic, interesting, and conducive to collegial professional exchange.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Session content and strategies will be useful in my work.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Today's learning objectives were met.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Comments:

What is the most significant thing you learned today?

____
____
____

What support do you need to implement what you learned today?

____
____
____

How will you apply what you learned today to your work?

____
____
____

How can we build on this session for follow-up training?

____
____
____

If you weren't satisfied with any part of today's session, please explain why.

____
____
____

Thank you very much for taking the time to complete this survey.
Your feedback is valued and very much appreciated!

Note. *Adopted from Technology-Based Professional Development for Teaching and Learning in K-12 Classrooms* by Byrd, N., 2017, copyright 2017, Walden Dissertations and Doctoral studies.

Using Microsoft Forms

How to access MS Forms

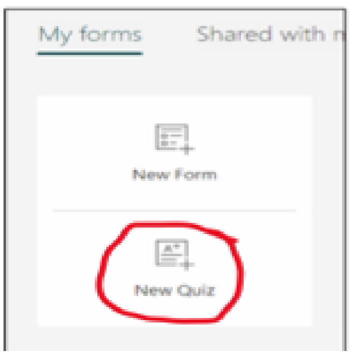
There are several different ways to access Forms:

- You can head to https://forms.office.com/ (make sure you're signed into your NTU account)
- Or go to the Office 365 home page and select **Forms**
- Or go to your NTU email account online (this can be accessed through MyNTU), click the box in the top left-hand corner, and under **Apps** click **Forms**

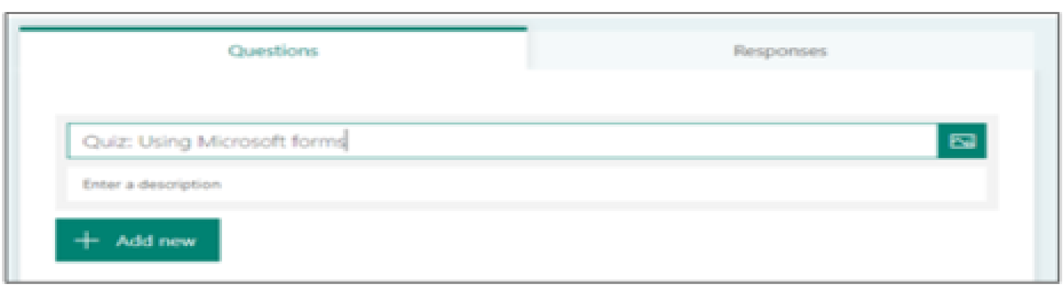
How to create a quiz

Quizzes are the same as forms but with the addition of **points per question** and **feedback**.

To create a quiz, access MS Forms and then select **New Quiz** (if a "Welcome to Microsoft Forms!" box appears, close it using the X in the top right corner).

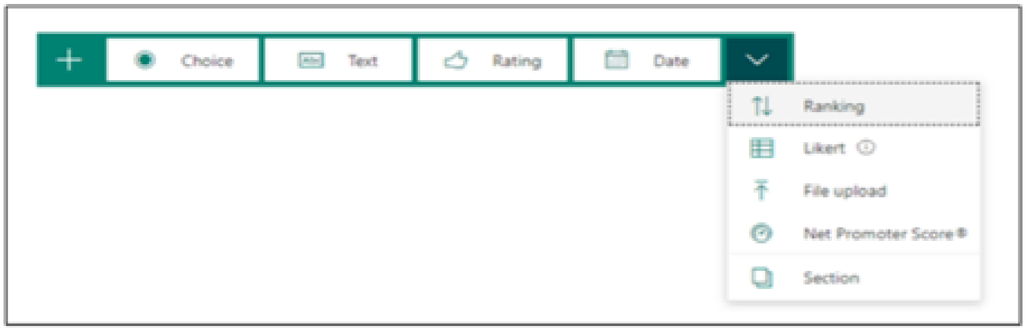


Enter a **title and description** for your quiz. If you would like to add an **image**, select the image icon on the right side of the title (standard copyright considerations apply). To add a question, select **Add new**.

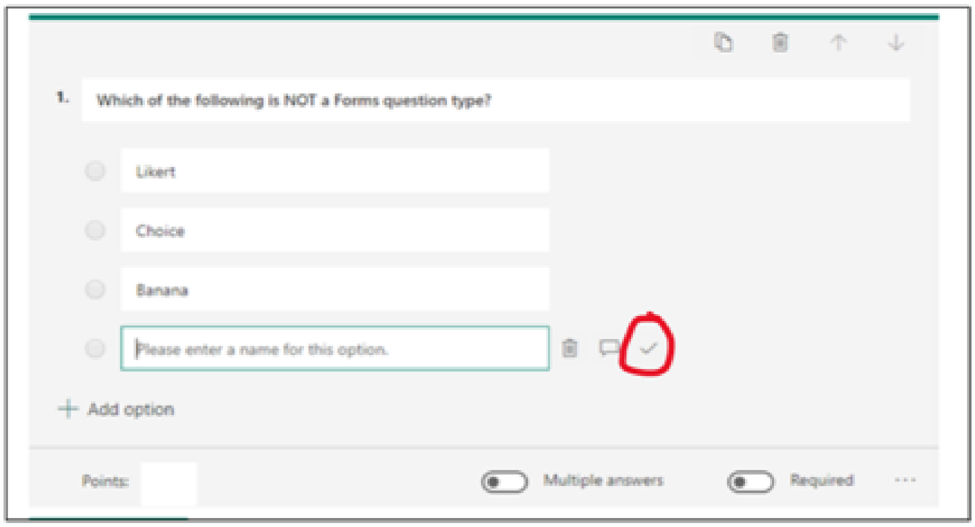


Select the type of question you'd like. **Choice** (multiple-choice question) and **Text** (text response) are likely to be the most useful, but you can also choose from:

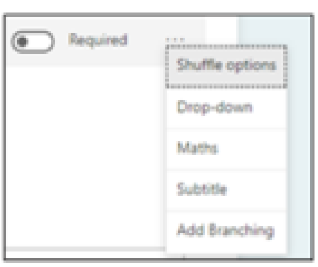
- Rating
- Date
- Ranking
- Likert
- File upload
- Net Promoter Score



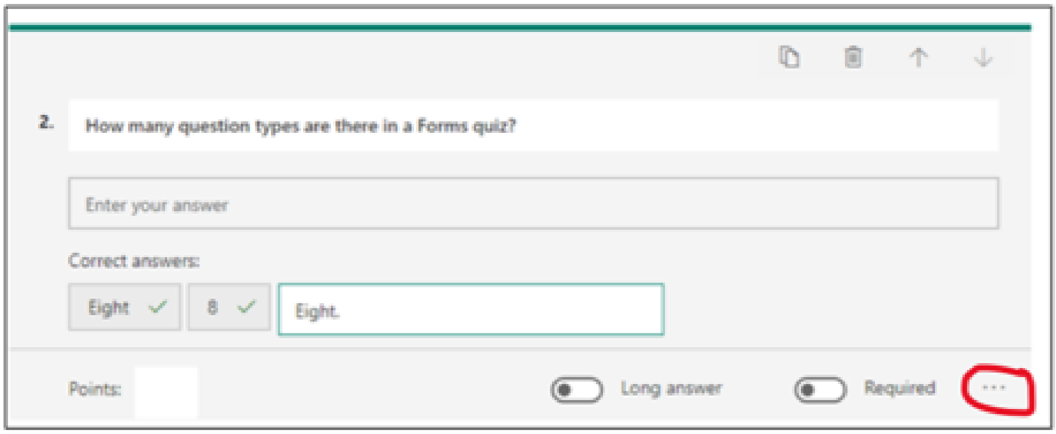
For multiple-choice questions, select **Choice** and enter your question and answer options in the boxes provided. To select the correct answer, use the tick by the side of the answer box.



If there are multiple possible answers, you can toggle the **Multiple answers** option and select all the correct answers. You can use the speech bubble  next to each answer to give **feedback** and also assign a question points using the **Points** box. Further options (such as the option to enter **mathematical formulae** or utilise branching) can be found by clicking on the ellipses  on the bottom right. Question and answer text is saved automatically.

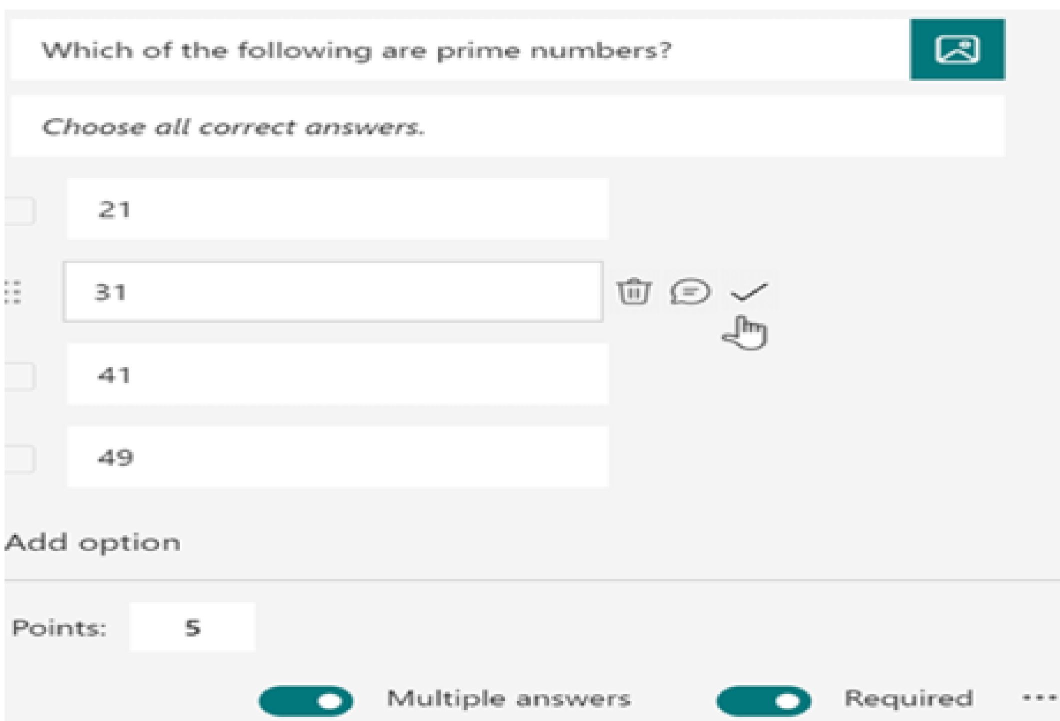


To create a new question, select **Add new**. For a text-based answer, select **Text** and enter your question and any possible answers. You may want to enter an answer multiple times with any spelling variations. For longer answers, select the **Long answer** option so that students are able to write more. Again, Further options can be found by clicking on the three dots on the bottom right.



To change the theme and colour of the quiz, select **Theme** in the top navigation bar and select one of the themes or colours.

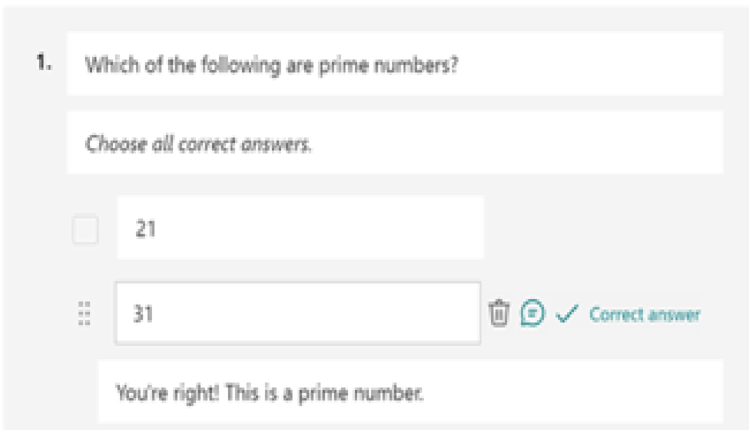
To check how your finished quiz will look to students, select **Preview** at the top right of the screen.



To remove an answer, select the trash can button next to it. You can also choose to make a question required or allow multiple choices for a question by changing the settings at the bottom of the question.

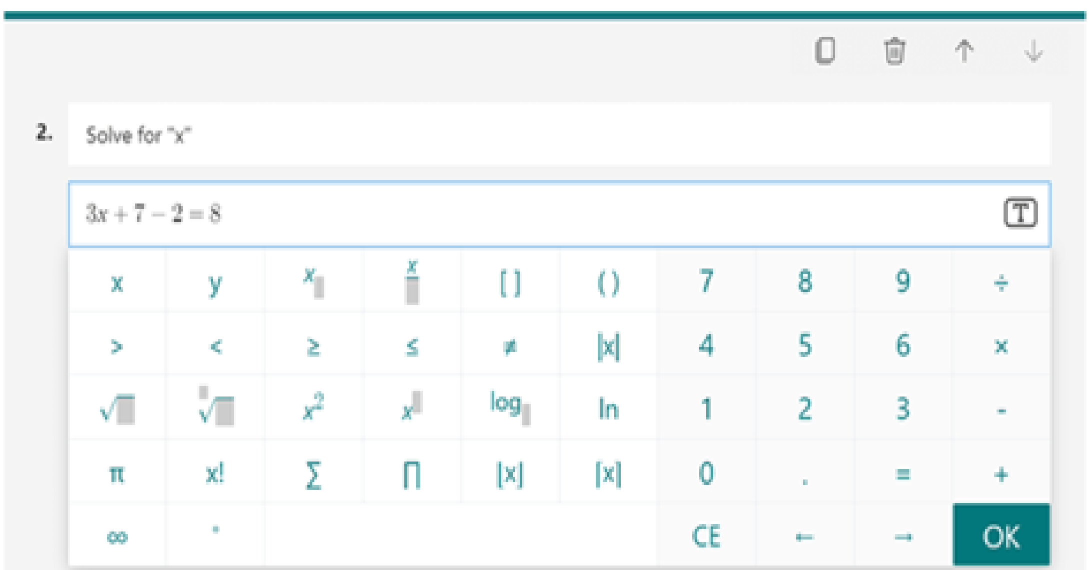
Add a number in the **Points** text box to assign a point value for a correct answer to the quiz question.

Select the **Message** icon next to any answer if you want to customize a message for it. Respondents will see the message when they've selected that answer.



To display math formulas, select **More settings for question** > **Math**.

Select **Enter an equation** to trigger various math symbols and formula options to use in your quiz.



Case study: Tracking Students' Performance in CSEC 2006- 2016

Table 12: Passes in CSEC and G-SAT Mathematics, 2000-2016

Year	Passes in G-SAT Mathematics (%)	Passes in CSEC Mathematics (%)
2000		37.70
2001		32.00
2002	51.00	36.00
2003	48.00	36.00
2004	44.20	23.50
2005	57.80	39.40
2006	53.00	35.70
2007	46.00	35.30
2008	55.00	43.00
2009	53.00	40.90
2010	57.00	44.70
2011	62.00	39.90
2012	63.00	37.50
2013	61.00	42.20
2014	60.00	55.50
2015	56.00	57.00
2016	57.00	44.00

Note*: Adopted from mathematics performance in Jamaica by Bourne*, P., 2019, p.21, copyright ResearchGate, 2019.