International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Implementation of e-Learning to Increase Mathematics Proficiency

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***Abstract*—** *There had been prolonged poor performance of Grade 11 students in the Caribbean Secondary Education Certificate mathematics examinations. This qualitative study aimed to explore secondary mathematics teachers' perceptions of implementing 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. A three-day blended professional development course was created to stimulate teachers' professional practices and develop self-efficacy in e-learning implementation in their classrooms.*

***Keywords*—** *Mathematics education, professional development, e-learning, teacher education, math instruction, self-efficacy.*

I. Introduction

The problem addressed in this study is the prolonged poor performance of Grade 11 students in the CSEC mathematics examinations. The Ministry of Education, Jamaica, statistics department 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 six 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).

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 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 to their teachers to improve learning. Developing problem-solving skills may enable students to increase their mathematics proficiency and pass CSEC mathematics.

II. Research Questions

Little was known about how secondary mathematics teachers implement mathematics e-learning in the classroom. This qualitative study aimed to explore secondary mathematics teachers' perceptions of implementing e-learning to teach mathematics and the support they receive to implement e-learning in the school. The following research questions guided the study:

A. What are secondary mathematics teachers' perceptions of implementing e-learning to teach mathematics?
B. What support do teachers perceive is needed for secondary mathematics teachers to implement e-learning in the classroom?

III. Conceptual Framework

The conceptual framework that grounded this study was 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

Gladstone Faulkner, Chris Cale, Michelle McCraney, and Sunddip Panesar-Aguilar, "Implementation of e-Learning to Increase Mathematics Proficiency," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 5, Issue 2, pp. 21-24, 2022.

(2016), the framework balances theoretical, technological, and practical knowledge, enabling teachers to design mathematics lessons using technology.

The TPACK conceptual framework development came from connecting the critical elements of TK, CK, and PK. In a scholarly discussion, Akturk and Ozturk (2019) argued that TK refers to knowledge, including advanced technologies such as the internet and digital videos. TK also provides traditional technologies such as chalkboards, 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 between 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.

IV. Methodology

Criteria for Selecting Participants

Over the last three years, this study's potential participants included 10 CSEC mathematics teachers using e-learning in their CSEC mathematics courses. Participants who matched these criteria would constitute a purposeful sample. Purposeful sampling is used to select information-rich cases for in-depth study. Information-rich cases have information about a phenomenon of vital importance to the study's purpose. Analyzing information-rich cases yields insights and in-depth understanding.

Participant Recruitment

To access the school for this study, an email was sent to the school's principal to introduce myself. It attached an invitation letter to conduct the study at the urban secondary school. The principal approved the invitation through a cooperation letter. The school did not provide any data or staff assistance for the study. Six teachers were selected 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

Due to COVID-19 restrictions, ten mathematics teachers participated in an online staff meeting, and all matched the selection criteria. Each potential participant was given an outline of the specifics of the study, including the requirements for participation. Teachers were ensured that their names and details would remain confidential. Participants who wished to participate returned the consent form with the "I consent" selection. Participants received no incentives for their involvement.

Data Collection

Data collection for this study consisted of interviews with six CSEC mathematics teachers. The intent was to conduct the interviews in the local setting. Flexibility was provided to participants if they preferred phone or Skype interviews. Open-ended semistructured interviews were used to gain insight into participants into the implementation of mathematics learning.

V. Data Analysis

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. All the recordings for each participant were reviewed and manually transcribed for coding purposes. Re-listening to each recording ensured that the appropriate insights for each participant's responses were captured. Member checking was used to review the findings for data accuracy.

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. Teachers are generally 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 (Rapanta et al., 2020).

Research Question 2

The second question aimed to understand teachers' support for e-learning in 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 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. Teachers need continuous PD training, which facilitates skill development required to respond to the 21st-century classroom. In addition, 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.

VI. Discussion

This research study 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 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.

The study was limited to secondary mathematics teachers but may apply to other subject disciplines. Also, the study was conducted independently 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 them. 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.

VII. Conclusion

A qualitative research study addressed an urban secondary school in Jamaica regarding mathematics teachers implementing e-learning in the classroom. The purpose was to explore secondary mathematics teachers' perceptions of implementing e-learning to teach mathematics and their support for implementing e-learning—semistructured interviews with teachers closely associated with the problem to understand this problem. After data analysis, four themes emerged, one subtheme as evidenced in the data analysis. First, although teachers showed CK, PK, and TK, there is a need for continuous PD training to develop new experiences among teachers.

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