Modeling Technology-Enhanced Instruction to Pre-Service Teachers: Reflection on Lessons Learned During the COVID-19 Pandemic

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ABSTRACT

Convincing teacher educators of the need to integrate information and communication technologies (ICTs) in their classrooms has become a less arduous task in the post-pandemic era since educational institutions were forced to shift to emergency remote delivery in early 2020. As a result, it has become very significant that pre-service teachers are fully prepared on how to integrate ICT in a 21st century classroom. This paper uses the experience of an introductory ICT in Education course taught during the pandemic to first-year university Bachelor of Education pre-service teachers as a reflection point for providing a review on lessons learned about technology integration. With no face-to-face instruction, several pedagogical strategies underpinned by the constructivist approach and supported by the Science Technology Mathematics & Engineering (STEM) methodology were incorporated into the course to equip students to integrate ICT effectively and competently in the teaching and learning process. The paper emphasizes the need for effective modeling of technology use by teacher educators to provide expert illustration/demonstration to pre-service teachers for future classroom practice. Further course recommendations and the implications for practice and research post-pandemic are provided as part of this review.

Keywords: *technology integration, pedagogy, STEM, role modeling, technology-enhanced instruction, teacher education, pre-service teacher, COVID-19, post-pandemic, Information and Communication Technology (ICT).*

INTRODUCTION

In today's digital age, convincing teacher educators of the need to integrate Information and Communication Technologies (ICTs) in their classrooms has become a thing of the past. The role of education in the 21st century, coupled with the core and interdisciplinary sets of skills required to meet the demands and challenges of work, life and the global economy (Battelle for Kids, 2019; Trilling & Fadel, 2012), has laid a foundation for change in teaching and learning, and in technology use in educational institutions. In teacher-training programmes, educator buy-in to the philosophy of ICT integration and the explicit inclusion of ICT in the teacher education curriculum are critical in preparing student teachers to utilize ICTs in their practice (Salmon-Ferguson & Barrett, 2018). However, such integration using an informed, pedagogical approach can prove challenging for student-teachers (Seifert, 2017).

In 2020, the COVID-19 pandemic and physical/social distancing protocols moved classes from face-to-face to a remote online mode. This increased the level and cost of Internet, videoconferencing and other web-based ICT technologies used as a means of connecting faculty members and students. Evidenced by the impact on technology and teacher education, the pandemic heightened the call for a focus on online pedagogical strategies, the development of resources to support online teaching, and ongoing professional development (Ferdig, Baumgartner, Hartshorne, Kaplan-Rakowski & Mouza, 2020). McElroy (2020) articulated that preparing teachers for technology integration in the face of radical change must start in teacher education programmes. Few would disagree that the educational experience in the pandemic was a radical change. The use of new ICTs was supported by an increase in educators' willingness to

adopt technology in education (Bleeker & Crowder, 2022). The increased knowledge and skillsets of teacher educators present a significant opportunity for equipping potential teachers with competencies to model effective technology use in their own instruction.

The conversation in this paper peers through the lens of an Information and Communication Technologies in Education (hereafter referred to as ICT in Education) course taught to first-year university Bachelor in Education degree students (pre-service teachers). The course is designed to equip students with knowledge, skills and competencies for integrating ICT within a 21st Century learning environment underpinned by the constructivist approach and STEM methodology. The shift to remote instruction during the pandemic necessitated a shift in thinking from the face-to-face strategies used to conduct teaching and learning activities, and an enhancement of the technology-based components. This paper discusses more than just teacher educators' increased use of technologies in teaching and learning. Rather, it reflects on the course experience during the pandemic to provide a unique perspective on delivering technology-enhanced instruction and emphasizes the need for teacher educators to model instruction to pre-service teachers for effective ICT classroom integration. The paper also discusses implications of the modeling approach for teacher education practice and research post-pandemic.

THEORETICAL CONTEXT

Introducing technology in education typically requires a change in pedagogical approach and instructional strategies. As the use of technology increases, educational institutions are asked to respond to national imperatives that will create technologically literate societies. How a society develops a technologically literate population is achieved through integrating ICT in the curriculum of educational institutions. The STEM approach to learning and development is Jamaica's choice for teacher education and integrating ICT in the teaching and learning process. STEM was introduced so that pre-service teachers could prepare students to face the challenges of globalization in a modern society that embraces science (Suwarma & Kumano, 2019). Leveraging the potential and affordances of the technologies used, diversifying teaching methods, and enhancing student ownership and responsibility for the learning process promote a constructivist approach to learning (Seifert, 2017). Woodrow, Mayer-Smith, & Pedretti (2000) suggested minimal whole class instruction and more student-teacher exchanges, implementing interacting assessment to encourage mastery, addressing variations in student learning styles and multitasking as examples of new strategies adopted by teachers to support technology integration in learning. Another example is an online teaching environment utilizing web tools and technologies such as forums, blogs, collaborative writing, surveys for group data collection and online peer assessment (Seifert, 2017). Merely having access to ICTs is not sufficient (Tondeur, Forkosh-Baruch, Prestridge, Albion & Edirisinghe, 2016), neither is merely learning about the tools and environments (Seifert, 2017). Technology by itself will not bring about classroom change unless teachers are open and willing to re-think beliefs, engage in experimentation, and are supported during the change process (Woodrow et al., 2000).

Much literature exists on teacher educators' competence in technology integration (Borthwick & Hansen, 2017; Foulger, Graziano, Schmidt-Crawford & Slykhuis, 2017) and which integration model or standards best guide technology use. Technological pedagogical content knowledge (TPACK) is a framework which helps educators to understand the interactions of the technology, pedagogy and content components, and how technology can be integrated in teaching (Koehler & Mishra, 2009). The PICRAT model of technology integration focuses on guiding teachers to move beyond using technology for passive instruction, to facilitating interactive and creative learning while promoting teacher reflection to replace, improve and transform pedagogical practices through technology use (Kimmons, Graham & West, 2020). To support pre-service teachers' competence

in integrating technology, Tondeur (2018) recommended a Synthesis of Qualitative Evidence (SQD) model with six strategies: teacher educators as role models, reflection on the role of technology, using technology by design, peer collaboration, authentic technology experiences, and the provision of continuous feedback.

In addition, several frameworks and standards guide educators' professional development and strengthen their use of technology to transform teaching and learning. The UNESCO ICT Competency Framework for Teachers (ICT-CFT) emphasizes teachers' ability to successfully integrate ICT into their classrooms, to guide the development of ICT competencies for students, and to help students develop skills such as collaboration, problem-solving and creative expression (UNESCO, 2018). The ICT-CFT framework, used by several countries, crossmatches knowledge acquisition, knowledge deepening, and knowledge creation with six areas — understanding ICT in education, curriculum and assessment, pedagogy, application of digital skills, organization and administration, and teacher professional learning (UNESCO, 2018). The European Framework for the Digital Competence of Educators (DigCompEdu, Redecker, 2017) provides a guide for the development of educators' digital competence using six main areas: identified professional engagement, digital resources, teaching and learning, digital assessment, empowering learners, and facilitating learners' digital competence. In a comparative analysis, Benali & Mak (2022) found significant alignment between the competences identified in the DigCompEdu (Redecker, 2017) and those in selected teacher-based digital competency frameworks, including the ICT-CFT.

The educator standards of the International Society for Technology in Education (ISTE) cover seven themes - Learner, Leader, Citizen, Collaborator, Designer, Facilitator, and Analyst - each drilling down into several criteria for helping educators deepen practice, promote collaboration, rethink traditional approaches and empower students (ISTE, 2017). Foulger et al., (2017) also provided a framework of twelve Teacher Educator Technology Competencies (TETCs) developed to assist teachers with redesigning teaching via competency areas such as designing instruction, incorporating pedagogical approaches, using effective strategies for teaching in online/blended environments, and troubleshooting technology issues; and each area has its own set of related criteria.

Modeling, in the context of technology integration, is a practical demonstration of technology use in the classroom (Kay, 2006). Several studies conclude that modeling technology in teaching is important in teacher education programmes (Foulger et al., 2017; Kay, 2006; Tondeur, 2018; Vannatta & Beyerbach, 2000) as it encourages technology use among pre-service teachers (Zipke, Ingle & Moorehead, 2019) and helps them prepare to integrate technology in their own teaching Tondeur (2018). In eight of the twelve TETCs by Foulger et al., (2017), the related criteria addressed teacher educators modeling these competencies, for example, modeling technology use for evaluating information, differentiating learning and conducting basic troubleshooting. However, given the potential for disconnect between the teacher education programme setting in which pre-service teachers are trained and the institutional setting where they are eventually placed, placing pre-service teachers into classrooms of teachers who model technology use is recommended (Zipke et al., 2019). One possible disadvantage to modeling is pre-service teachers not getting the chance to "construct their own technology-based lessons" (Kay, 2006, p. 391).

REFLECTIONS ON LESSONS LEARNED

In the ICT in Education course offered to pre-service teachers, students are expected to understand ICT as the basis for integration, explore standards and policies governing the appropriate use and integration of ICT, demonstrate the integration of various ICT tools and applications, and exhibit competences and attitudes to support their professional development as digital practitioners. This expectation is grounded in the constructivist approach and STEM methodology. Pre-COVID, face-

to-face instruction involved lab-based activities, presentations, demonstrations, discussions and other interactive learning activities while technology-enhanced components of the course focused on e-portfolio preparation, forum discussions, journaling, and out-of-class engagement with instructors. Shifting from face-to-face to emergency remote delivery called for more technologies to be incorporated in the course interactions to facilitate technology integration.

Perhaps the most poignant lesson learned from the pandemic is that achieving the objectives of ICT integration courses requires careful and deliberate planning and design. Regardless of pedagogical strategies, any major shift or pivoting of this process requires an exponential, not linear, re-balancing of efforts to ensure success. A deliberate, timely approach is necessary to ensure teacher educators go beyond mere technology inclusion (Tondeur et al., 2016; Woodrow et al., 2000).

In the course, technology integration activities were determined from course objectives and the weekly course outline. This allowed alignment of the technology integration activities and course content (Vannatta & Beyerbach, 2000). Classes were conducted using different web conferencing tools to enable pre-service teachers to draw conclusions about the tools' effectiveness. For a class focusing on assessing learner progress using ICT tools, a game-based platform was used to develop and model a quiz activity to assess understanding of ICT-related concepts. Similarly, an online poll was created to assess and demonstrate how to obtain learner feedback on strategies, aligning with one TETC to "model a variety of assessment practices that use technology" (Foulger et al., 2017, p. 432). Using technology to grade and provide feedback on electronically submitted student assignments (Redecker (2017) was also demonstrated for their discussion paper assessment. Where teacher educators reuse teaching materials, a review of assessment rubrics will be necessary to consider the evaluation of delivery skills such as effective eye contact and non-distracting movements, not reading from notes and effective use of time. Otherwise, students in remote locations may experience technological challenges which impact effective presentation delivery.

Another lesson learned was demonstrating technology usage, even in non-practical classes. Pre-service teachers who observed instructors modeling technology integration were positive about technology use (Vannatta, 2000; Vannatta & Beyerbach, 2000). Given that interactive learning with technology promotes meaningful learning (Kimmons et al., 2020), pre-service teachers' engagement in, and teacher educators' modeling of the technology are necessary to provide maximum learning effects. For example, students were required to use an online collaborative tool to author a discussion paper, show argument development using mind-mapping software, and evidence group participation through the tool's tracking and revisions feature. The facilitators also provided periodic feedback via the same tool, thereby demonstrating application features such as versioning, commenting and tracking of individual input activity. On reflection, an additional activity could have been designed to demonstrate co-creation of content, such as teacher educators and pre-service teachers developing rules for using an instant messaging platform to extend learning outside the classroom. Empowering learners (ISTE, 2017) and actively using tools during instruction through hands-on activities are critical in fostering learner engagement (Redecker, 2017).

An e-portfolio assignment was given to facilitate visibility of knowledge and skills on using and integrating ICT in education. The required components included self-introductions, reflections, and samples of work which demonstrated accomplishment of ICT skills. Students could choose to do samples from technologies and tools demonstrated weekly by the facilitators, consistent with teacher educators being able to "model approaches for aligning the content being taught with appropriate pedagogy and technology" (Foulger et al., 2017, p. 432), or from those discovered on their own. Consistent with Zipke, Ingle, & Moorehead (2019), student e-portfolios demonstrated

confidence with the technology tools, not only with the quality of the samples created, but through their written reflections on how their ICT skills improved over the period.

Foulger et al., (2017) recommended that teachers should "model the legal, ethical, and socially responsible use of technology for teaching and learning" (p. 433). While various related topics have been incorporated into the content, the remote learning environment provided additional opportunities to reinforce responsible use of technology. This was most relevant, for example, with practical demonstrations on sourcing and using images, videos and other resources, and through providing appropriate feedback on students' use of tools to promote responsible use.

Technological challenges beyond one's control can thwart the best plans. In the course, both instructors and pre-service teachers experienced bouts of intermittent connectivity, particularly during long periods of audio or video streaming. Teacher educators' responses to such challenges provide a source of learning to pre-service teachers who will need to find ways to address similar challenges when they enter the classroom. During the course, an instant messaging platform was used to provide updates on such issues and to facilitate consultation outside of class. The platform also facilitated student sharing of resources, such as videos, on related class topics. How pre-service teachers engage with their educators during extenuating circumstances should be considered in future planning.

Before the year 2020, instructors delivering the course modelled technology-enhanced instruction using the face-to-face modality. In the physical space, visually modelling technology-enhanced behaviours in the psychomotor, cognitive and affective domains was ideal, however the affective domain on the part of the students is seldom seen in the remote setting primarily because they are not required to turn on their camera. This minimized the ability to view students' body language to determine interest and appreciation of content delivery. Technological interruptions during remote delivery due to access, type of devices and connectivity (data or Wi-Fi) challenged some students' ability to participate in class. One recommendation is to provide alternative electronic means of instruction and accessing content. This can also benefit the future teachers in how to address technological challenges in their future classrooms. Bleeker & Crowder (2022), in discussing the challenge of reduced access to online learning among marginalized populations and special needs students during the pandemic, highlighted zero-rated websites, consolidation of online content and device procurement as some initiatives introduced to expand access.

With the level of digital infrastructure, technologies and online tools for teaching and learning implemented during the pandemic (Bleeker & Crowder, 2022), eliciting the successful components of both remote online delivery and face-to-face instruction, resulting in a blended or hybrid approach, may prove beneficial post-pandemic, despite the potential for unexpected challenges. This may require dedicated teacher time and effort but can also serve as an opportunity for teacher educators to model technology-enhanced instruction without having to deal with challenges such as technological connectivity, inability to fully assess the affective domain, including observing students' body language, lack of individualized attention, difficulty with classroom engagement and other hindrances to effective student learning. Surma & Kirschner (2020) highlighted three instructional principles of effective face-to-face education - worked examples, practice and feedback, and stimulating metacognition, that is, guiding students on a path to successful individual learning - as a guide to designing technology-enhanced distance learning. Teacher educators may not necessarily have the choice to determine learner mode of delivery, however, if these principles are weaved into the design of technology-enhanced instruction and are effectively modeled, it could result in enhanced preparation of pre-service teachers for the classroom.

IMPLICATIONS FOR TEACHER EDUCATION PRACTICE AND RESEARCH

It is unlikely that a single strategy will provide the solution to teacher preparation for integrating technology in education. However, modeling how technology is selected and used in remote delivery environments can help pre-service teachers develop approaches to technology use that they can adapt in similar or more effective ways in the future, having learned from the successes and failures of their educators. Even if teacher educators had been engaging in modeling prior to 2020, the COVID-19 pandemic provided a background for enhanced technology use to address unstructured situations.

Designing technology-enhanced instruction is instrumental in the modeling of technology use. Carefully planned learning activities are necessary to seamlessly and visibly expose pre-service teachers to technology integration content and strategies they can expect to use in their future classrooms. Connecting technology integration activities to course content and deliverables helps to minimize the frustration that technology is merely an accessory (Vannatta & Beyerbach, 2000). Setting aside time for designing instruction to facilitate modeling can help with selecting appropriate ICT tools for teaching delivery.

The length of exposure to modeled technology-enhanced instruction may also affect pre-service teachers' ability to effectively integrate what they learn after completion of their programmes. Salmon-Ferguson & Barrett (2018) posited that ICT integration should be evident in the entire curriculum of teacher education programmes in technical and vocational education and training (TVET). Modeling technology use for pre-service teachers throughout the duration of their teacher education programmes provides them with authentic learning experiences and can allow them to exit the programmes with minimal need for re-training. Polly, Byker, Putman, & Handler (2020, p.250) suggested that TPACK provides a lens for teacher educators and clinical educators (described as "teachers who host teacher candidates in their classroom") to discuss and model technology integration to ground and support teacher candidates' understanding of the connections among the various TPACK components.

Generally, ongoing professional development is needed to help teachers increase their knowledge, skills and attitudes towards the integration of technology in teaching (Foulger et al., 2017), in particular, how they model technology to their students. Teacher/instructor training is perhaps the area most necessary for the integration of ICT and technology enhanced learning (TEL) into curricula (George, 2015). Given that teachers may be the most influential factor in classroom education, training on how to effectively use ICT and how to instruct students on effective ICT use (UNESCO, 2012) is critical. Thus, attention should be given to equipping teachers to efficiently integrate ICT in their work (Benali & Mak, 2022), particularly for teacher educators with degrees earned long before the proliferation of today's ICT tools and technologies and who may not fully grasp the value of teaching with technology (Koehler & Mishra, 2009). Scheduling time to facilitate training and development is important to equip existing teacher educators or for onboarding new ones. At an institutional level, educational administrators may also consider evaluating existing theoretical models used to guide technology integration (Kimmons et al., 2020; Koehler & Mishra, 2009) and adapt accordingly to encourage levels of consistency among its teacher educators. At the same time, increasing educators' capacity and autonomy to integrate technology, though not at the expense of a uniform ICT integration approach, and developing leadership capabilities for promoting online learning integration (Bleeker & Crowder, 2022) may be warranted. Budgetary allocations for emergency expenditure on infrastructure, such as enterprise software subscriptions and computer equipment, may also have to be considered for some institutions depending on their procurement approval processes. If not, teachers and in some cases, students, may find it difficult to adapt.

In a broader context, the year 2020 placed nearly every course in teacher education programmes in the category of technology-enhanced courses. Role-modeling the technology used in instruction across content, pedagogy, assessment, global connections and other areas of competencies (Foulger et al., 2017) is recommended among these changes. The third level (Knowledge Creation) of the ICT-CFT focuses on teachers acquiring competencies to model good practice and to encourage students in their knowledge creation (UNESCO, 2018). The establishment of a common set of teacher technology competencies will encourage professional development (Borthwick & Hansen, 2017). Disparate curriculum and policies, and differences in teacher training programmes may challenge how this is achieved (UNESCO, 2012). Regardless of the framework or standards used, teacher educators should reflect on the effectiveness of the strategies used to plan, design and deliver their courses, and contemplate any needed changes in pedagogical strategies as they seek to integrate and model technology-enhanced instruction.

The return of educators to post-pandemic classrooms poses new implications for delivering technology-enhanced instruction. UNESCO (2023) highlights the importance of technology as complementing, but not substituting, face-to-face interaction with teachers, and suggests the effective use of technology to facilitate student-centred learning and personalized student learning experiences, even while recognizing barriers such as teachers' lack of access to infrastructure and confidence in using technology. The UNESCO report also recognizes that technology is changing teacher training through, among other things, creating flexible learning environments, supporting coaching and mentoring, and increasing reflective practice; and it also highlights education systems such as ICT standards and frameworks which assist in promoting systematic training and ongoing teacher professional development (UNESCO, 2023).

Research on how integrated strategies and frameworks such as TETCs (Foulger et al., 2017) impact technology integration in education can provide evidence-based results which can highlight gaps and stimulate further work on their effectiveness. Combining other strategies with modeling technology in instruction can also be studied to identify best practices across various contexts within the educational domain. What are pre-service teachers' views or perceptions on its inclusion in a technology-enhanced course? Are there learner characteristics that respond more favourably to modeling? Does modeling technology use lend itself more readily to particular learning environments, settings, content areas or age groups, and to what extent do pre-service teachers demonstrate competence or change in attitudes based on their exposure to this modeling? How does modeling technology use affect pre-service teachers' perceptions of technology? (Zipke, Ingle, & Moorehead, 2019). Martin (2019) found that peer support and adequate technical support are important factors in determining pre-service TVET teachers' perceptions of their readiness to integrate ICT into the curriculum. Martin (2019) also recommended sharing prior teaching experiences with those without experience. Further research could provide empirical evidence on the learning impact of these approaches.

Teacher educators' perspectives on modeling technology use also provide opportunities for future research. Should every learning activity be modeled or only some? What guiding principles, standards, pedagogical strategies or theoretical models should be used for modeling? What is the ideal technological learning environment for instructional modeling? There is no shortage of research opportunities that exist with the modeling of technology use as a pedagogical strategy. It could be argued that effective technology use and integration would best occur with a combination of strategies, rather than with a singular focus, however studies on both perspectives are warranted to determine which approach yields optimal learning effects. Investigating learner perceptions on technology-enhanced learning post-pandemic is essential as technology use during the pandemic may have been the only option for ensuring learning continuity (Ironsi, 2022).

Documenting the experiences of teacher educators during the pandemic, such as the online pedagogical strategies used, new forms of collaboration and field experiences, innovative

approaches to delivery, and using digital tools to facilitate instruction (Ferdig et al., 2020), as well as lessons learned and success stories from technology-enabled learning implementations, including the development of policies on ICT in Education, use of open educational resources and open licensing (George, 2015), can contribute to institutional archives or serve as discussion points on best practices and how to pivot when faced with major disruptions. Our course experience, for example, included the recording of classes to facilitate playback by students who experienced technological challenges, using technological tools to support student engagement and periodically asking students to share their computer screens to check their progress.

Retrospective reviews with teacher educators can yield rich qualitative feedback and should be encouraged as plans are made to facilitate modeling technology use. Seifert (2017) recommended mentoring student teachers on ICT integrated-teaching throughout their teaching education duration and practicum. Longitudinal studies following pre-service teachers' transition to in-service teaching could also be conducted to determine the long-term impact of modeling technology use on their own classroom practices. Communication between teacher educators and clinical educators on the technologies that are valued can help to determine the effectiveness of pre-service teachers' experiences (Polly et al., 2020). Additionally, research on the use of teacher competency frameworks and the modeling of post-pandemic technology enhanced instruction within hybrid or face-to-face classrooms can yield insights to improve learning.

CONCLUSION

Changes in pedagogy and instructional strategies are usually warranted when technology is introduced in education. There was a considerable increase in the use of educational technologies in response to the COVID-19 pandemic (UNESCO, 2023). An ICT in Education course designed to provide pre-service teachers with the skills and competencies for integrating ICT served as a point of reflection for a practical examination of the modeling of technology-enhanced instruction by teacher educators. The discussion highlighted the contribution of modeling to effective technology integration for 21st Century classrooms. In addition to theoretical models and pedagogical strategies to inform and guide effective technology integration, this paper has advocated for incorporating role modeling within technology-enhanced and technology integration courses to make learning visible to pre-service teachers and to drive success in their integration of technology when they become practitioners.

Teacher educators will need continuous training and professional development opportunities to enhance their competence in technology integration to effectively model these skills, or where already in place, to share best practices with colleagues. Regional or institutional contexts may influence the best practices or competency standards or frameworks to be used. If technology-enhanced instruction is effectively modeled for pre-service teachers for online, remote, hybrid or face-to-face delivery, during a pandemic or otherwise, the classrooms of educators will produce students for the opportunities and challenges they will meet now and in the future.

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