



# Transitioning to Online Teaching During the COVID-19 Pandemic: an Exploration of STEM Teachers' Views, Successes, and Challenges

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## Abstract

Due to the COVID-19 pandemic, school closures were mandated by governments across the globe. This necessitated an abrupt shift to online/distance teaching. Through a mixed-methods study, the authors explored STEM teachers' transition to online teaching and learning in a Canadian context. This subset of the larger study investigated (i) teachers' views of and attitude toward online teaching and (ii) successes and challenges encountered with online teaching. Data were collected through an online questionnaire administered to 70 Grade 1–12 science/STEM subject teachers in a Canadian province between May and July 2020. Findings are discussed through the lens of self-efficacy theory and the technological pedagogical content knowledge (TPACK) framework. Results indicate that despite few successes, teachers faced a wide array of challenges that negatively affected their attitudes and views toward online teaching, and that the support received did not parallel their expectations. Teachers' experiences, self-efficacy, and technological competency slightly enhanced their views of online teaching but were not sufficient to shift their mindset. Recommendations include effective professional development initiatives and support for teachers to facilitate teachers' transition and enhance their personal views toward online teaching.

**Keywords** Emergency remote teaching · Self-efficacy · Science, technology, engineering, and mathematics (STEM) education · Technological competence

## Introduction and Objectives

The COVID-19 pandemic forced the closure of most K-12 schools around the world, thus abruptly shifting teaching to an online format. In Canada, school closures were in effect

from March to June 2020, with a number of strategies for transitioning to online teaching set forth by governments. For example, a provincial ministry of education mandated online/distance teaching for all K-12 students, articulating that elementary teachers focus on mathematics and literacy, while secondary teachers focus on literacy, math, and sciences, with a notable emphasis on science, technology, engineering, and mathematics (STEM) subjects. Teachers were also provided with learning platforms (e.g., Brightspace, Google Classroom) and a handful of suggested resources to implement during this process.

A review of the literature (Arnesen et al., 2019; Bekele & Menchaca, 2008; Saadé et al., 2007) reveals that research on online teaching is focused more so on postsecondary rather than K-12 education. Since online teaching was a first-of-a-kind experience for many educators, it is therefore crucial to explore K-12 STEM teachers' experiences in this new teaching and learning environment. Furthermore, there is a dearth of literature related to online teaching in K-12 schools in a Canadian context. Thus, the overall study focused on Canadian STEM teachers' online practices during the COVID-19 pandemic and focused on their views and attitudes, online

## Highlights

- Due to the COVID-19 pandemic, schools shifted to online teaching.
- Canadian STEM teachers' experiences with online teaching and learning were explored.
- Teachers expressed generally negative attitudes toward online teaching during the pandemic.
- Teachers faced an array of challenges that negatively impacted their views toward online teaching.
- The support received by teachers did not parallel their expectations.

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teaching tools and resources, curriculum development and implementation, models of assessment, student outcomes, and successes and challenges encountered with online teaching. When referring to attitudes, the authors adopt Eagly and Chaiken's (1993) definition, which states that an attitude is "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (p. 1). On the other hand, teachers' views reflect teachers' opinions and prospects of how successful their experiences were, the extent to which they would integrate similar technologies in the future, and the reasons behind such stances (Merriam-Webster, n.d.). In this paper, the authors focus on teachers' experiences with online teaching during the pandemic, their perceptions of online teaching, as well as successes, and ongoing gaps. Specifically, the authors address the following questions: (1) What are STEM teachers' views of and attitudes toward online teaching during the pandemic? and (2) What successes and challenges did teachers encounter while teaching online from a distance? Given the timely and pressing nature of emergency remote teaching (ERT) (Hodges et al., 2020), the study is important as it documents teachers' experiences during the first year of the COVID-19 pandemic. Furthermore, findings will inform educational systems in order to better prepare them for future disruptions.

## Literature Review

### Online Teaching

#### Definitions and Rationale

Online learning, a specific form of distance or remote learning, is the process of learning with some or all instructional materials delivered over the Internet, with the teacher facilitating the process by structuring and sequencing the online activities (Cook & Steinert, 2013). Online learning tools are defined as, for example, websites, software, or computer-assisted activities that intentionally focus on and facilitate learning via the Internet (Saadé et al., 2007). According to Vivolo (2019), there are several online learning formats: (1) technology assisted in which in-person learning occurs, with technology introduced into the classroom as a means to augment learning; (2) blended, hybrid, or flipped in which part of the learning that is normally reserved for in-person interaction takes place in an online environment; and (3) fully online in which lectures, discussions, and activities occur in a digital environment, void of in-person engagement.

Fully online teaching can also take several forms— asynchronous and synchronous. Asynchronous learning is any non-real-time learning or communication that is not live and facilitated through video, audio, a document, a program, an application, or engagement tools such as

discussion board forums, virtual chat rooms, or email. In asynchronous online classes, students can engage in learning, without the presence of others in the virtual space. On the other hand, synchronous learning occurs with real-time or simultaneous interaction with a person or group of people. Classes are offered in a way that students are online and communicating concurrently. Examples of real-time tools include webinars, video chats, live streaming, or those integrated into social media platforms (Tallent-Runnels et al., 2006; Vivolo, 2019).

Due to the advancements in technology, online teaching/learning has evolved in the last 20 years, leading to its adoption by many higher education institutions around the world, and to a less but growing extent in the K-12 educational system. Moreover, the ubiquity of technology and ease of access to online resources, combined with emerging learning and instructional theories have created new venues for online teaching (Hung & Jeng, 2013). Accordingly, many students choose online learning modules as they provide them access to high-quality learning at a convenient time; they are earning degrees or learning new courses without traveling to a different city or country. Nevertheless, after school closures globally due to the COVID-19 pandemic, the transition to online teaching became mandatory rather than by choice. The abrupt transition was aimed at ongoing learning and the only resort for educational systems in such unprecedented times (Barron Rodriguez, 2021; Selvaraj et al., 2021). Due to the unique circumstances of online teaching during the pandemic, Hodges et al. (2020) introduced the term ERT and defined it as "a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances" (p. 6). Hodges et al. (2020) maintain that the conditions for effective online learning include careful instructional design, planning, and development, as well as an investment in the support systems. These conditions may be lacking in emergency situations such as the COVID-19 pandemic, which would reduce the quality of online teaching. The current study explores the conditions highlighted by Hodges et al. (2020), related to teaching and learning and specifically to challenges and successes encountered by teachers as they engaged in curriculum planning and development, and implementation during ERT.

#### Prevalence of Online Teaching in Education

Online teaching offers innovative tools for education. This has led institutions of higher education to re-examine their policies and regulations originally written for traditional classrooms and to adopt technology as an essential tool to increase their global outreach and advance their competitiveness (Hung & Jeng, 2013). In the USA, for example, enrollment in online learning is growing at an exponential rate. In the 2000–2001 academic year, 90% of public 2-year

and 89% of public 4-year institutions offered distance education courses. In the same year, an estimated 2,876,000 individuals were enrolled in college-level, credit-granting distance education courses, with 82% of these at the undergraduate level (Tallent-Runnels et al., 2006). In 2012, all 50 states were offering K-12 online learning opportunities. Some states such as Michigan, Alabama, New Mexico, and Idaho have passed legislation requiring K-12 students to complete at least one online learning experience by the time they graduate high school (Kennedy & Archambault, 2012).

In Canada, online teaching is more prevalent in higher education than in K-12 education. In 2018, there were more than 1.3 million online course registrations, representing 8% of all course registrations in Canada. In 2019, more than two-thirds of all Canadian public universities and colleges offered online courses for credit (Johnson, 2020). Compared with the recent dramatic expansion of digital learning in the USA, online learning in Canada's K-12 public schools has followed a decidedly different pattern of evolution. Canadian provinces and territories have established and maintained "distance education" programs within their K-12 publicly funded school systems. For example, prior to the pandemic, one Canadian province announced that starting in 2020–2021 the delivery of all e-Learning courses will be centralized with secondary students taking a minimum of four e-Learning credits out of the thirty credits needed to fulfill the requirements for graduation (Anderson, 2019). Making online learning mandatory is a high-risk endeavor. It will succeed—in terms of learning outcomes—only if students get adequate teaching and support online. Although this study explores STEM teachers' experiences during ERT, findings will provide evidence as to the required preparation of teachers with enhanced digital competencies for the successful launch and implementation of provincial e-Learning mandates in the future.

### Affordances of Online Teaching

Research has demonstrated many affordances associated with online teaching. First, it overcomes physical distance as a barrier to learning, allowing for more versatility and flexibility. This flexibility includes freedom from reliance on time and space associated with traditional classrooms (De Paepe et al., 2018; Hofer et al., 2021; Thoms & Eryilmaz, 2014; Vivolo, 2019). From a pedagogical perspective, online teaching has a positive impact on teaching and assessment strategies (Cook & Steinert, 2013; Hung & Jeng, 2013). Teachers can incorporate effective pedagogical and instructional strategies such as games, interactive models, computer simulations and animations, and audio and video clips for learners to engage in meaningful knowledge construction. The multimodality and availability of these rich resources are definitely advantageous (Eichler & Peeples, 2013; Vivolo, 2019). Online

digital resources can enrich the classrooms and improve student learning (Recker et al., 2013), as they provide high-quality and collaborative online learning experiences both synchronously and asynchronously (Hoffman, 2018; Selvaraj et al., 2021). The flexibility provided by asynchronous online teaching modules specifically, and the video format utilized in teaching were shown to positively impact student achievement in a university robotics course (Birk et al., 2020). Thus, digital tools aimed at helping students construct their knowledge within real-world circumstances and create learning communities in which students interact, discuss, and share with other students, can provide benefits over synchronous online teaching.

With respect to assessment, online teaching helps optimize or personalize the learning experience for individual students through computer-adaptive instruction and can facilitate assessment by providing tailored feedback (Dietrich et al., 2021). Online assessments can also provide timely and corrective feedback (Dipietro, 2010; Vonderwell et al., 2007), thus enabling students to evaluate their progress and teachers to reflect on their practices (Faber et al., 2017). Hence, online environments can also be powerful for developing collaborative and creative authentic assessments (McVey, 2016). Assigning interactive quizzes, assessments, and activities can reduce boredom and increase interaction with course materials (Smith et al., 2018). Innovative assessments can include activities such as projects, portfolios, self-assessments, peer evaluations, and immediate feedback (Gaytan & McEwen, 2007). For example, van Ginkel et al. (2019) report on how artificial intelligence can be used to provide detailed and analytical feedback to students on their oral presentations resulting in enhanced oral presentation skills.

Studies have highlighted the positive impact of Internet-supported learning on students in terms of grade achievement, motivation, participation, and satisfaction (Bekele & Menchaca, 2008; Higgins et al., 2019). A systematic review of 92 studies showed that the use of digital tools can enhance learning and student outcomes in secondary school mathematics and science students (Hillmayr et al., 2020). Amasha et al. (2018) attribute improved student performance to students' enhanced motivation due to the synchronized integration of online learning and assessment. Online teaching also positively impacts student engagement (Dumford & Miller, 2018), as well as learner agency and autonomy (De Paepe et al., 2018). Additionally, Broadbent (2017) reports that students learning online utilize self-regulated learning strategies such as time management, metacognition, critical thinking, and effort regulation more often than students in blended-learning environments. These strategies have significant positive correlations with academic success in online settings (Broadbent & Poon, 2015).

To attain the sought affordances, several factors are crucial such as students' digital and regulation skills and

a proper technological infrastructure (Hofer et al., 2021), suitable and equitable access to technology especially in emergency situations (Eberle & Hobrecht, 2021), as well as continuous teacher training (Hillmayr et al., 2020). Lohr et al. (2021) maintain the importance of a comprehensive approach aimed at ensuring the success of online teaching rather than isolated measures. Such an approach includes a digitalization policy, commitment of the administration, quality equipment, technical and educational support, and digital skills and technology-related teaching skills. In the current study, the authors explore the level of attainment of the aforementioned affordances during ERT, for example, choice of digital tools, assessment strategies, student engagement and outcomes, and equitable access, to name a few.

### Constraints and Challenges of Online Teaching

Several obstacles and challenges face online teaching, including those associated with administration, students and teachers, pedagogy, and equity. In terms of administrative challenges, online teaching requires investments in time and money for development and maintenance. As well, the deficiency in instructional designs and valuable resources and the required technical support necessitate a large investment in time and money. Moreover, the rapid advancements in technology require constant improvements in order to keep abreast of hardware and software. This poses risks for school boards and governments in the areas of technical support and budgetary constraints (Cook & Steinert, 2013; De Paepe et al., 2018).

Student challenges include isolation and the lack of face-to-face interaction, which could be addressed via synchronous real-time interactions and social networks (De Paepe et al., 2018; Dumford & Miller, 2018). Moreover, several studies highlight the technological challenges students face, pointing to the importance of enhancing students' digital literacies, in addition to issues related to learners' motivation and engagement to learn using these technologies (Cook & Steinert, 2013; Davis et al., 2007; Lao & Gonzales, 2005; Leire et al., 2016; Saadé et al., 2007; Zhang & Lin, 2020).

Teacher challenges include the fact that online technologies are time consuming and require high-quality teacher preparation. Effective professional development (PD) focusing on integrating TPACK (Koehler & Mishra, 2009) would enhance teachers' knowledge, technological competency, and self-efficacy in online teaching. Enhanced TPACK has the potential to impact the quality and rigor of online teaching (Álvarez et al., 2009; Barnes et al., 2018; Lao & Gonzales, 2005; Saadé et al., 2007; Tinoca & Oliveira, 2013). Research studies (Jung, 2005; Smith et al., 2016) reiterate the importance of PD for in-service teachers and teacher education, with a focus on curriculum development and assessment

using online resources, strategies for interacting with students asynchronously, and developing technological skills. Research also suggests that instructors' competence is crucial to the quality of the courses, which directly affects student learning outcomes (Lowenthal et al., 2018; Zhang & Lin, 2020). Hence, continuous attention to course design and teacher capacity is warranted (Leire et al., 2016).

From a pedagogical perspective, and despite numerous teaching and learning resources, challenges in teaching and assessment strategies continue to exist. For instance, individualizing learning in online courses rarely goes beyond managing the pace of learning (Cook & Steinert, 2013). In addition, students are less likely to engage in collaborative learning, which may be due to fewer interactions and discussions compared to traditional classrooms (Dumford & Miller, 2018). Correspondingly, several studies have highlighted the critical role of assessment especially homework, formative assessment, and feedback while teaching remotely (Amasha et al., 2018; Eichler & Peebles, 2013; Tinoca & Oliveira, 2013). Teachers have reported reduced opportunities for immediate and personalized feedback leading to less support and guidance for students (De Paepe et al., 2018).

In terms of equity, those who were marginalized before the pandemic are now even more at risk. The assumption that every single student has the necessary technology, time, motivation, and support to participate in distance learning is unrealistic. Rural and low-income communities have less access to broadband Internet than their urban, suburban, and more affluent counterparts. Equity and access to the required technologies, including software and equipment limit opportunities to participate (Lao & Gonzales, 2005; Rohleder et al., 2008). Without access to technology, it is difficult to develop a technical skill, and it is redundant to have access to technology without first having the skill to utilize it. Students from disadvantaged communities are further at risk of not pursuing educational opportunities due to the lack of access to the Internet, computer devices, software for the completion of their studies, and/or the needed support and skills. Thus, the overall effect is a significant impact on the participation of marginalized and minority groups in the workforce.

It is worth noting that the age of teachers is reported to be one of the factors that play a role in the extent and quality of implementation of technological tools in their teaching. Geeraerts et al. (2018) noted, based on a study with Belgian and Finnish teachers, that teachers reported learning innovative teaching methods and information and communications technology (ICT) skills from younger colleagues, whereas the older colleagues usually supported their peers by providing content knowledge and classroom management skills. ICT knowledge and skills included the use of software for developing digital resources, digital learning environments, and online tools. Hence, younger teachers are more likely

to use more innovative teaching methods and develop more innovative course materials. This is reiterated by Badia et al. (2017) who tested the effect of various demographic factors affecting 965 university teachers' approaches in online teaching. They concluded that age and academic background are important predictors of the adoption of a particular approach to teaching online (content acquisition approach, collaborative learning approach, or knowledge building approach), while gender and online teaching experience, for instance, are not. Furthermore, younger teachers appear eager to learn more about their practice during PD sessions, and are more willing to become better teachers (Angelides, 2004). Accordingly, the impact of age will be particularly highlighted in addition to other demographic factors in an attempt to understand whether these factors played a role during ERT.

This study aims to highlight the affordances as well as constraints related to ERT among STEM teachers during the COVID-19 pandemic. Based on the research objectives, this study provides concrete evidence as to what teachers were experiencing during the ongoing pandemic; evidence related to personal struggles, teaching contexts, administrative supports, student learning; and digital resources. Moreover, it provides insights into the preparation or lack thereof of teachers to engage in ERT during unprecedented times.

## Theoretical Framework

In order to teach STEM effectively, teachers need proficiency in STEM pedagogical content knowledge (Shulman, 1986) as well as increased self-efficacy in teaching content (Tschannen-Moran & Hoy, 2001). Similarly, when integrating technological tools in teaching, teachers need enhanced TPACK and self-efficacy in online teaching. The TPACK framework is related to both (a) teachers' thought processes and knowledge, and (b) teachers' actions and their observable effects (Koehler & Mishra, 2009), which are directly related to teachers' self-efficacy (Bandura, 1995) and mindset (Dweck, 1999). Thus, the theoretical frameworks are informed by TPACK and self-efficacy as they complement each other, and are suitable to predict and interpret STEM teachers' views and attitudes during ERT throughout the COVID-19 pandemic.

### TPACK

TPACK is a framework used by researchers to better understand how teachers support student learning through technology integration in their practice (Voogt et al., 2013). The three major constructs combined in this framework are technological knowledge (TK) or knowledge about technologies for use in teaching and learning; pedagogical knowledge (PK) or processes and methods of teaching and learning;

and content knowledge (CK) or subject area understandings (Pringle et al., 2015). Although Baturay et al. (2017) found TK to be the biggest indicator of technology inclusion in practice, it is the complex interactions among these three elements in specific contexts that define teachers' ability to teach effectively (Koehler & Mishra, 2009). Combining these constructs, both theoretically and practically, would produce the knowledge needed to successfully integrate technology into teaching.

TPACK is, in addition to mastery of content knowledge, pedagogical knowledge, and pedagogical content knowledge, the integration of these practical and theoretical types of knowledge. Teachers need to artfully incorporate technologies to enhance student learning by capitalizing on their capabilities to support and promote learning, while at the same time being aware of the interdependence of technologies and subject content knowledge. Hence, the TPACK framework offers several possibilities for promoting research in teacher PD and teachers' use of technology to move beyond oversimplified approaches that treat technology as an "add-on" in teaching (Koehler & Mishra, 2009). This framework has led to significant recommendations regarding subject-specific pedagogical instruction, ICT education, and increased opportunities for the use of technology in teacher education programs (DeCoito & Richardson, 2018).

### Self-Efficacy Theory and Mindset

Self-efficacy is "the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1995, p. 2). It is a task-specific belief that regulates choice, effort, and persistence in the face of obstacles and in concert with the emotional state of the individual. The task-specific focus of self-efficacy distinguishes it from more global concepts such as self-esteem or confidence (Bray-Clark & Bates, 2003). Teaching efficacy is defined as personal beliefs about capabilities to help students learn (Ashton & Webb 1986, as cited in Schunk, 1991). Teachers' self-efficacy is made up of a belief in their ability to effectively teach (efficacy beliefs), as well as a belief in their students' ability to effectively learn from their teaching (outcome expectancy) (Riggs & Enochs, 1990). Accordingly, these beliefs about teaching and learning have a great impact on teachers' behavior and performance, and subsequently their practice (Davis et al., 2006). Aldunate and Nussbaum (2013) found that teachers who incorporated technologies were more likely to continue with more complicated systems rather than abandoning them altogether. In terms of educators, Goldstein et al. (2013) define mindsets as "assumptions and expectations we have for ourselves and others that guide our teaching practices and our interactions with students, parents, and colleagues" (p. 74). Furthermore,

Gemino et al. (2018) note the difference between fixed and growth mindsets, with the former being resistant to change while the latter fosters building skills with work and effort. Thus, mindset leads to external action and can be changed.

Bringing change to teacher practice has to start with a change in their belief systems. Teachers' self-efficacy beliefs should translate directly into the quality of their practice (Woolfolk et al., 2009), and thus, an increase in teachers' outcome expectancies will reflect a greater belief in their students' abilities to succeed. Self-efficacy, TPACK, and mindset influence teachers' efforts and persistence in terms of incorporating and utilizing online technologies in their practice. For instance, teachers whose self-efficacy is low might avoid planning classroom activities involving online technologies that they believe exceed their capabilities, be unlikely to persist with students who are having difficulties with online technologies, expend little effort to locate teaching materials that align with online technologies, and not reteach content in ways students might understand better. In contrast, teachers whose self-efficacy is higher might develop challenging activities using online technologies, help students succeed, and persevere with students who are encountering challenges with technology. These motivational effects enhance student learning and substantiate teachers' efficacy by conveying that they can help students learn (Schunk, 1991). Research suggests that positive self-efficacy beliefs can increase the extent to which teachers are willing to transfer skills learned during in-service training to the classroom, and can lead teachers to explore alternative and improved methods of instruction (Bray-Clark & Bates, 2003).

Teachers' proficiency in terms of the TPACK framework, combined with high levels of self-efficacy and growth mindset are important for their success in online teaching and learning, and are critical in ERT, acknowledging personal and systemic challenges that accompany emergencies. Thus, these theoretical lenses are well suited for interpreting and discussing study findings in relation to ERT during the pandemic.

## Methodology

### Research Design

This study utilizes a mixed-methods design. In specific, a convergent mixed methods design is utilized as both quantitative and qualitative data were collected concurrently but analyzed separately. The results were then compared to confirm or disconfirm each other (Creswell & Creswell, 2018). Quantitative and qualitative data were collected from teachers through an online questionnaire, including open-ended questions. Teachers were recruited through

their school board email, teacher associations, and social media. Due to the social distancing measures implemented, online questionnaires were the most convenient means of data collection in the setting of a large Canadian province. Given that teachers were busy throughout the period of data collection (May–July 2020), and to avoid additional angst, we chose not to interview participants. Accordingly, triangulation in terms of data sources was not possible. Yet, our aim was to obtain both comprehensive quantitative and rich qualitative data that detail teachers' experiences with online teaching. Each of the quantitative and qualitative data sets was analyzed separately. The two databases were then integrated to compare results, with qualitative data providing details and insight about the quantitative data. This was conducted to ensure the trustworthiness of the data.

### Participants

The questionnaire was administered to STEM teachers from different locations in a Canadian province. Participant recruitment methods included snowball sampling through teacher networking and referral (Parker et al., 2019). Teachers were invited to participate in the study through email from school boards and teacher associations. In addition, researchers and consenting teachers recruited additional participants via social media (e.g., Twitter, Facebook, LinkedIn). As a result, 40% of the participants are from the province's central school boards, 53% of them from school boards in the West of the province, and 7% of them from other locations in the province.

Participants represented various demographics in terms of the grades taught (elementary and secondary), age groups, teaching experience, and education. Participants included STEM subject teachers (biology, chemistry, environmental sciences, physics, earth sciences, general science, technology, and mathematics). Teachers' education included those with bachelor's degrees (72%) and graduate degrees (masters or doctorate, 28%). In terms of age, 74% of the teachers are between 31 and 50 years, 13% are between 21 and 30 years, and 13% are above 50 years. Teaching experience varied with 11% of the respondents having less than 5 years of teaching experience, while 89% have more than 5 years of teaching experience (26% between 6 and 10 years, 39% between 11 and 20 years, and 24% above 20 years). Finally, 51% of the participants teach elementary and middle-school grades (grades 1–8), while 49% teach high school (grades 9–12). Table 1 details the distribution of teachers' demographics in relation to each age range. It is worth noting that while the majority of teachers have a bachelor's degree, most of the teachers with a graduate degree are between 31 and 50 years of age, and possess between 6 and 20 years of teaching experience. Moreover, results of the Spearman correlation illustrate

**Table 1** Details of teachers' demographics: distribution of teachers within each age range

Age (years)	Sample ( <i>n</i> )	Grades taught		Educational background		Teaching experience (years)			
		Gr. 1–8	Gr. 9–12	Bachelor's	Graduate	1–5	6–10	11–20	20+
20–30	9	4	5	6	3	6	3	0	0
31–40	19	12	7	13	6	0	10	9	0
41–50	33	17	15	24	8	2	4	14	13
51–60	7	2	5	5	2	0	1	4	2
61+	2	0	2	1	0	0	0	0	2
Total	70	35	34	49	19	8	18	27	17

One teacher did not indicate their class taught, and two teachers did not indicate their educational background

a strong positive correlation between teachers' age and their teaching experience ( $r_s=0.61$ ,  $p<0.01$ ).

### Data Sources

In order to obtain rich descriptions and detailed insights, participants responded on a 5-point Likert scale to 24 statements and five open-ended questions. Questionnaire items were adapted from Barberà et al.'s (2016) cross-national study of teachers' perceptions of online learning success. The open-ended questions were developed from the literature based on online environments and taking into consideration the ongoing ERT. The statements and questions explored teachers' (i) views and attitudes toward online teaching, (ii) curriculum planning and implementation, (iii) assessment and student outcomes, (iv) successes and challenges, (v) support during the transition to online teaching, and (vi) recommendations for enhancing the quality of online teaching experiences for teachers and students alike.

In this study, teachers' reflection on practice to evaluate the quality of teaching and learning experiences in online environments during ERT is warranted. Hodges and Fowler (2020) maintain that teachers' reflections can lead to better teaching practices and better preparation for instructional situations such as ERT. Reflection can be defined as the careful examination and bringing together of ideas to create new insights through ongoing cycles of expression and reevaluation (Marshall 2019, as cited in Hodges & Fowler, 2020). Both aspects (statements and open-ended questions) of the questionnaire required teachers to reflect on their practice. In this paper, data related to teachers' views and attitudes toward online teaching (i, above) and successes and challenges (iv, above) were analyzed.

Sample Likert scale items that reflect teachers' attitudes toward online teaching are as follows:

- The transition to online teaching was smooth.
- The amount of workload for me, as a teacher, was fair.
- In general, I believe that online teaching during the pandemic is a positive experience for students.

- In the coming year, I would integrate more online components into my teaching practices.

Sample qualitative questions that detail teachers' attitudes and reflect their views toward ERT are as follows:

- List some challenges that you face(d) as a teacher while preparing for or implementing online teaching. Please elaborate on how you address(ed) these challenges.
- List the successes you have noted during online teaching. Please elaborate on strategies that led to your success.
- Please suggest additional strategies that the Ministry of Education need to consider to enhance the quality of online teaching experiences for students and teachers alike.

### Data Analysis

This paper is based on 70 participants as data saturation (Charmaz 2006, as cited in Creswell & Creswell, 2018) occurred in the qualitative data obtained from open-ended questions. Correspondingly, similar trends were highlighted in the quantitative data. Qualtrics, a web-based software used for data collection enabled the researchers to view and perform initial and ongoing analysis of the data. For instance, Qualtrics highlights the percentages for quantitative data and illustrates themes via word clouds for qualitative data. Based on the ongoing observation and analysis of the data, the authors chose to cease data collection as new categories and themes beyond those identified were not evident. For example, additional data did not elicit new themes related to challenges encountered by teachers beyond those identified in the "Results and Discussion" section—professional time constraints and personal circumstances; fostering and maintaining student engagement; navigating technological and technical challenges with attention to equity; lack of support and professional development; locating appropriate digital resources and teaching methods; assessment practices and plagiarism; collaborating with families; and lack of direction from leadership/administration.

Once data saturation occurred, all data were exported from Qualtrics. Quantitative data analysis was conducted in MS Excel and SPSS. Descriptive statistics were performed in addition to various statistical tests to investigate the relationship or the correlation between various factors. Specifically, the Mann–Whitney *U* Test was performed to explore the relationship between certain demographic data (class taught and educational background) and teachers' attitudes. This is because each of the demographic variables is a nominal variable composed of 2 categories (elementary/secondary for classes taught and undergraduate/graduate for background), whereas teachers' attitude indicators are ordinal variables (5-point Likert scale). Also, the Spearman correlation test was performed to explore the relationship between other demographic data and teachers' attitudes. These demographic data (teaching experience and teacher's age) and the teachers' attitude indicators are both ordinal variables (5-point Likert scale), thus requiring the Spearman correlation test (Connolly, 2007).

To address the research questions, qualitative data from open-ended responses were analyzed through an interpretational analysis framework, using NVivo 12 data analysis software and executed through the process of thematic coding and constant comparative method (Stake, 2020). Participants' reflections were inputted directly into NVivo 12, and emerging codes were generated. These codes were then explored and interpreted to seek context as some words carry equal or similar meanings. Thereafter, similar codes were combined into themes. Thematic coding was performed independently by both authors to enhance the trustworthiness and consistency of the analysis. The open-ended responses were analyzed by each of the authors separately. Thereafter, the authors discussed the coding results and clarified discrepancies in coding certain phrases. The themes were analyzed for frequency among participants in order to illustrate common successes, challenges, and recommendations.

## Results and Discussion

### Attitudes Toward Online Teaching

#### General Trends

As shown in Table 2, 55.7% of the respondents indicated that the transition to online teaching was not smooth; 51.4% encountered an unfair workload, while 82.9% agreed that they faced challenges throughout online teaching. Although 81.4% rated their own competency as high for using online teaching technology, the majority did not envision online teaching during the pandemic as a positive experience for teachers (67%) nor students (73%). On a positive note, around 60% of the teachers indicated they would integrate more online components in their teaching practices in the coming year, thus signaling perhaps a change in mindset (Goldstein et al., 2013). These results indicate a general dissatisfaction among participants in terms of online teaching and could be due to heavy workloads and challenges they faced. Despite the teachers' beliefs in their technological competence, their evaluation of the online teaching experience did not reflect this and was mostly negative in terms of impact on teachers and students. The reasoning behind these generally negative views and attitudes toward online teaching is further captured in the support received and the challenges faced by teachers, as detailed and discussed in section "[Challenges in Online Teaching](#)."

#### Relation between Teachers' Age and Their Views of Online Teaching

Teachers' age was not correlated with their views of online teaching. Results of the Spearman correlation indicate a weak correlation between teachers' age and their views of the transition to online teaching ( $r_s = -0.05$ ,  $p = 0.69$ ). Sixty-seven percent of the teachers between 20 and 30 years and 42% between 41 and 50 years agreed that the

**Table 2** Teachers' questionnaire responses focusing on their attitude toward online teaching

Statement	Strongly disagree	Somewhat disagree	Unsure	Somewhat agree	Strongly agree
Smooth transition	25.71%	30.00%	2.86%	34.29%	7.14%
The workload was fair	18.57%	32.86%	2.86%	40.00%	5.71%
Challenges during online teaching	10.00%	4.29%	2.86%	42.86%	40.00%
High competency using online teaching technology	2.86%	11.43%	4.29%	41.43%	40.00%
Online teaching during the pandemic is a positive experience for teachers	35.71%	31.43%	10.00%	15.71%	7.14%
Online teaching during the pandemic is a positive experience for students	40.00%	32.86%	17.14%	7.14%	2.86%
I would integrate more online components in my teaching practice	4.29%	15.71%	20.00%	41.43%	18.57%



transition to online teaching was smooth. As well, 68% of the teachers aged 31–40 years and 71% of those between 51 and 60 years disagreed with this statement. Correspondingly, results of the Spearman correlation indicate a weak correlation between teachers' age and their views of the challenges in online teaching ( $r_s = 0.24, p = 0.05$ ). The vast majority of teachers agreed that they faced challenges in online teaching, with similar trends among different age groups.

### Relation Between Teachers' Experience and Their Views of Online Teaching

Results of the Spearman correlation indicate a weak correlation between teachers' teaching experience and their views of the transition to online teaching ( $r_s = -0.17, p = 0.17$ ). Around 50% of teachers with teaching experience between 1 and 10 years agreed that they experienced a smooth transition to online teaching. Yet, 70% of teachers with experience between 11 and 20 years and 53% of teachers with more than 20 years of experience disagreed with this statement. On another note, results of the Spearman correlation indicate that there was a moderate positive correlation between teachers' teaching experience and their views of the challenges in online teaching ( $r_s = 0.32, p < 0.01$ ). For example, 75% of teachers with less than 5 years, 67% of teachers between 6 and 10 years, 93% of teachers between 11 and 20 years, and 88% of teachers with more than 20 years of experience agreed that they faced challenges in online teaching.

In analyzing the relation between teachers' age and teaching experience on attitudes toward online teaching, it is evident that age and teaching experience was not related to the transition, although experienced teachers reported facing more challenges. This may be due to the fact that younger teachers possess digital literacy, or they are TPACK ready (Mouza, 2016). Age and teaching experience can be linked to better subject matter/content knowledge and pedagogical experience. Yet, it appears that all groups of teachers needed better preparation in order to shift to online teaching. Such preparation affects teachers' TPACK (Koehler & Mishra, 2009), self-efficacy (Bandura, 1995), and mindset (Goldstein et al., 2013), thus impacting their attitude toward online teaching.

Despite the overlap between age and teaching experience, survey data revealed that the majority of teachers experienced challenges. Qualitative analysis revealed several themes related to challenges, including professional time constraints; locating and selecting appropriate digital resources; fostering and maintaining student engagement; collaborating with families; plagiarism; lack of support; navigating technological challenges; assessment practices; and lack of leadership/administrative direction.

### Relation Between Teachers' Educational Background and the Challenges they Faced

The Mann–Whitney  $U$  test indicates no difference between teachers who possess undergraduate versus graduate degrees in terms of challenges they faced during this transition. Graduate degrees may provide teachers with better content/subject matter knowledge and/or scholarship in their subject, in general. In both cases, teachers' educational background was not related to their attitudes and views toward online teaching during the pandemic.

### Relation Between the Classes Taught and Teachers' and Students' Experiences

The effects of grades taught (whether elementary or secondary) on student and teacher experiences were investigated using the Mann–Whitney  $U$  Test. Results indicate no differences between elementary and secondary level teachers when exploring the effect of online teaching on both student and teacher experiences. Surprisingly, both elementary and secondary teachers demonstrated similar trends in terms of disagreeing with online teaching being a positive experience for both teachers and students. This further rebukes the assumption that students in higher grades are technologically competent and able to navigate online learning seamlessly, thus impacting their engagement and motivation to learn online. This is not the case, as when it comes to online learning, students need support, modeling, and opportunities to practice a range of skills (Pangrazio, 2018).

### Relation Between Teachers' Technological Competency and Their Views of Online Teaching

Results of the Spearman correlation indicate a moderate positive correlation between teachers' evaluation of their own technological competency and their views of the transition to online teaching ( $r_s = 0.35, p < 0.01$ ). Ninety-two percent of teachers who agreed and all teachers who strongly agreed that they experienced a smooth transition to online teaching were those who rated themselves as highly competent. This parallels the literature on the importance of self-efficacy (Bray-Clark & Bates, 2003; Davis et al., 2006) and technological competency complementing content and pedagogical knowledge (Álvarez et al., 2009; Barnes et al., 2018; Lao & Gonzales, 2005; Saadé et al., 2007; Tinoca & Oliveira, 2013) to ensure smooth online teaching experiences.

Furthermore, results of the Spearman correlation indicate a weak correlation between teachers' technological competency and their views of the challenges faced in online teaching ( $r_s = -0.12, p = 0.31$ ). Teachers' self-evaluation as high or low competency did not impact the fact that they faced challenges. Similarly, results of the Spearman correlation

indicate a weak correlation between teachers' technological competency and their positive experiences in online teaching ( $r_s = 0.25$ ,  $p = 0.03$ ). Even teachers who self-reported technological competence disagreed with the statement that online teaching was a positive experience for them.

Finally, a weak correlation between teachers' technological competency and their willingness to integrate more online components in their future teaching ( $r_s = 0.08$ ,  $p = 0.52$ ) was noted. For instance, teachers who consider themselves highly competent are fairly distributed among different levels of agreement as to whether they would integrate more online components in their future teaching practice. This is an opportunity for PD initiatives that can potentially change teachers' mindset (Goldstein et al., 2013). An exploration of the reported challenges is warranted, given that they may be directly impacting teachers' self-efficacy, experiences with and attitudes toward online teaching, and their mindset to integrate more technological tools in their practices. As noted before, 60% of the teachers indicated they would integrate more online components into their teaching practices in the coming year.

## Successes Experienced in Online Teaching

Participating teachers reported several successes resulting from their online teaching experiences. The following themes were derived from teachers' responses to open-ended questions focusing on their successes: higher student engagement; utilizing digital tools and platforms; higher student autonomy; meaningful student and teacher communication; enhanced teacher creativity and professional learning; increased parent engagement; enhanced twenty-first century competencies; and opportunities for differentiating instruction (Fig. 1).

For most teachers (59%), the online platforms increased student engagement. There were two subthemes expressed by participants: students who find face-to-face participation challenging (e.g., such as quieter students or those

who experience anxiety) and those requiring differentiated instruction. Teachers commented.

*Some of the quieter students became more engaged or spoke up more during 1-on-1 meetings.* (Secondary biology and chemistry teacher)

*Some students with anxiety actually flourished at home in a quiet, calm safe environment.* (Elementary science and technology and math teacher)

As for differentiated instruction, teachers referred to self-pacing and personalized feedback. Teachers commented.

*Students could follow at their own pace, whether ahead or behind, and can continue to reference the information after they have finished the course.* (Secondary chemistry and math teacher)

*I was able to engage in modified guided reading sessions using appropriately levelled texts.* (Elementary science and technology and math teacher)

*Seeing students who were not normally engaged in the classroom completing all the assignments online. I truly think it was the individualized feedback that helped them.* (Elementary health and physical education teacher)

Furthermore, teachers (53%) expressed that the pandemic forced them to develop a personal catalog of digital tools to support learning, specifically upon their return to the in-school learning environment. In addition, teachers (24%) found that the experience forced them to immerse themselves in the professional learning of "new digital methods." Teachers noted that they acquired new digital literacy skills, often by self-learning. This enhanced their own creativity (24%), facilitated their assessment strategies online, and in turn positively impacted their students' motivation to learn and achieve their goals. Teachers commented.

*I learned how to use a variety of new tools. Also, I learned how to use technology tools to create engaging 3-part lessons. I was proud of many of the lessons I created, and the students were enthusiastic about them too.* (Elementary science, technology, and math teacher)

*I learned a lot about content creation and available free programs and resources to meet curriculum expectations in an interesting way for students.* (Elementary science, technology, and math teacher)

*I was more successful in delivering feedback. It was easy to give the same feedback to students and typing is faster than writing. There was flexibility in marking due to the pandemic. Students did better on creative assessment.* (Secondary math teacher)

Teachers (10%) also expressed that the online learning experience fostered and enhanced twenty-first-century skills

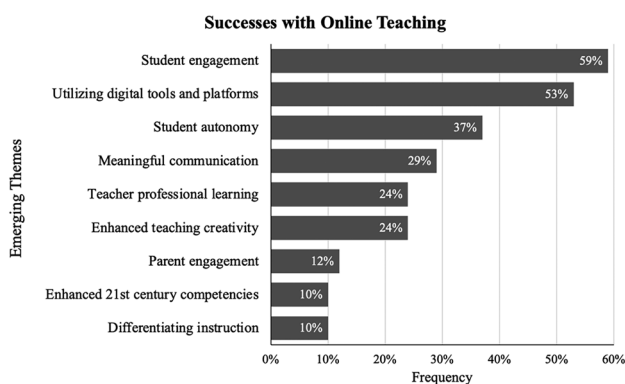


Fig. 1 Teachers' reported successes with online teaching

in students. Many teachers (37%) specifically mentioned that student autonomy was fostered in the online learning environment. Teachers said.

*There were a few students who really excelled at a more independent learning method. They motivated themselves and worked through a bevy of online activities.* (Secondary science and math teacher)

*I learned that it can be successful to give students more responsibility and ownership for their learning.* (Secondary biology teacher)

Finally, it is very important to note that some successes were connected to teachers' communities of practice. As well, prior PD impacted teachers' successes with online teaching. In reference to collegial cooperation, teachers stated.

*My department has worked very closely on a daily basis – helping each other and sharing resources.* (Secondary biology teacher)

*I have become much more proficient and comfortable using online platforms/programs/tools; through trial-and-error as well as sharing strategies with colleagues.* (Secondary science and math teacher)

As for the importance of prior preparation and exposure, teachers noted.

*We used technology in our classroom before online teaching and my students and I both felt prepared when we had to work virtually* (Elementary math teacher)

*I was already digital with all my content (100%); so, my transition was a smooth one.* (Secondary science and math teacher)

In summary, online teaching resulted in positive impacts on student outcomes as well as teachers' technological competencies and pedagogical practices. These promising successes are achievements that educators can share and build on to attain the maximum benefit in online teaching environments.

## Challenges in Online Teaching

Participants reported a wide array of challenges that were time consuming and hindered the transition to online teaching, resulting in less efficient teaching and learning experiences. The following themes were derived from teachers' responses to open-ended questions: professional time constraints and personal circumstances; fostering and maintaining student engagement; navigating technological and technical challenges with attention to equity; lack of support and PD; locating appropriate digital resources and teaching methods; assessment practices and plagiarism; collaborating

with families; and lack of direction from leadership/administration (Fig. 2).

The main challenge, experienced by 51% of participants, was dealing with time constraints and personal circumstances. For instance, balancing professional time boundaries had a negative impact on teachers' experiences and mental health when teaching online during the COVID-19 pandemic. Many teachers expressed an obligation to be available at all times. In addition, teachers felt that developing and assessing online learning products required additional time beyond the workday. Teachers expressed.

*Students tried to contact me on many different platforms, so I would miss messages and get them too late. I became neurotic about checking all the platforms as soon as I logged in. I maintained regular but extended contact working hours online, from 8am to 5pm, although I would grade and prepare afterwards. Students would regularly contact me with questions at 9pm and expect to get an answer for something due the next day.* (Secondary science and math teacher)

*The amount of time it takes to reinvent everything to be online is overwhelming/ trying to find interactive, engaging activities/ it leaves very little time for marking.* (Secondary biology teacher)

*We had to spend a lot of time just learning the platform which took away from instructional time and made true assessment of learning difficult.* (Elementary science and technology and math teacher)

*I pretty much worked 8+ hours a day, seven days a week, just to keep everything running.* (Secondary math teacher)

Furthermore, personal circumstances added heavy burdens and additional time constraints on teachers, as described by a secondary science and math teacher:

*I cried more during this time than I have since I was a beginning teacher. I have three kids at home. I had to help them with their learning. Juggling all this while*

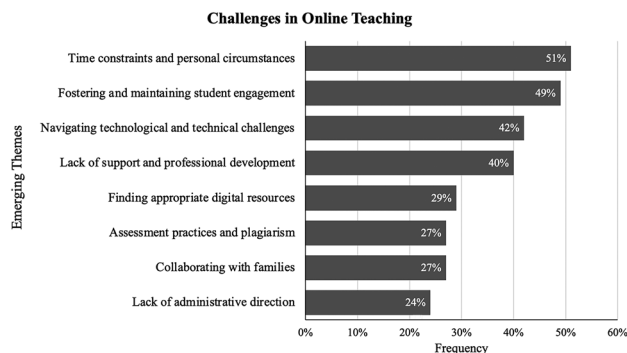


Fig. 2 Challenges noted during online teaching

*spending so much extra time creating online resources meant I had many weeks where I averaged 5 hours of sleep a night, and some nights when I had no sleep at all.*

Fostering and maintaining student engagement online was challenging for 49% of teachers. This was magnified especially under public communication from the government, which stressed basing students' grades on the assessments done before the transition to online teaching. This negatively impacted student accountability and caused participation online to significantly decrease by the end of the year. Some teachers also linked the lack of student engagement to students' social and emotional states such as feelings of isolation, sadness, depression, and disconnect from teachers and colleagues due to school closures.

Additional concerns included a lack of leadership/administrative direction (24%) due to ongoing changes from the government and challenges related to collaborating with families (27%) who were not necessarily encouraging their children to keep up with their online learning. Teachers expressed.

*The government kept changing what was required and unclear communication from the Ministry made things even more challenging for me to understand what the expectation for teaching was ... (Secondary biology teacher)*

*After March 13, the students knew that their grade could not change and therefore some decided to not complete any assignments. I think if we started a semester online and the students knew the course content was to count then the collaboration and student engagement would improve. (Secondary science and technology teacher)*

*Constantly begging the students to complete work and submit it; send hundreds of emails and do many Google meets to try and get them to engage in their learning. I found that the weaker students, the ones who need the most help and direction in class did not join meetings, or complete work. They did not engage at all and ignored my messages for extra help, these were the hardest to reach many did not do any online work. (Secondary biology teacher)*

*You cannot tell parents and students here is the platform, then learn about another one and tell the parents and students, sorry you just figured that one out, we are using this now... (Secondary science teacher)*

During the implementation of online learning, 42% of teachers expressed frustration in navigating a variety of technological issues. This included a lack of high-speed Internet, either for themselves or their students, thus making it challenging to provide synchronous instruction, and a lack of equipment forcing teachers to purchase for

themselves. Furthermore, teachers felt obligated to provide IT support to families because their students were struggling to access the online learning environment. Teachers commented.

*Internet connection was choppy at best. I was regularly disconnected or had a very poor connection during my synchronous teaching using Google Meet. (Elementary math teacher)*

*Lack of equipment, like a printer and a document camera, I had to purchase my one stylus pen, which did not happen till later on. (Secondary math teacher)*

On a related note, teachers highlighted inequity among students including Internet accessibility, parental support and availability, and groups of students disadvantaged more than others. Teachers said.

*For my special needs' students, my greatest challenge was not being able to be side by side helping them. Unless a parent or sibling was there helping them, they struggled with joining or participating in the activity. (Secondary physics and chemistry teacher)*

*Not having the entire class able to be online due to lack of internet access. (Elementary health and physical education and design and inquiry teacher)*

Finally, 29% of teachers found the process of locating free high-quality digital resources and appropriate teaching methods to be challenging. Often, digital resources needed to be tweaked and adapted to support both the provincial curriculum and learner needs. These challenges were further accentuated by teachers in the French immersion program who struggled to find bilingual resources. Teachers commented.

*A HUGE amount of time went into planning and trying to find resources which would cover the curriculum and be engaging. I had 3 courses to prep for, and very limited resources. My school does not have a budget for many resources, so it was difficult to find things that work that were free. (Secondary science teacher)*  
*The lack of resources meant I often had to reinvent the wheel. I could not find the resources I needed online because I teach French Immersion so any resources, I could find that had the content I wanted were too difficult for my students to understand. I had to create most of my resources for my students. (Elementary science teacher)*

*The interactives that have been created for the new online e-Learning courses during the last three or four years do not teach students concepts. They are mostly 'push a button and read things' interactives. (Secondary science teacher)*

*I have not found a way to replace real labs, which require planning and problem-solving and data analysis not available on any website. They all do most of the set-up for you, and the results are too perfect.* (Secondary science and math teacher)

Twenty-seven percent of teachers reported challenges related to assessing their students online, acknowledging the potential for plagiarism (Yeung et al., 2018) that renders their assessment unauthentic. Teachers stated.

*Quiz-type evaluations had to be up for hours or days. I assumed they were all done open book, many with help.* (Secondary science and math teacher)

*Providing individualized feedback online to students took approximately 4 hours per class per assignment. It was a grin and bear it type situation and I do not know if any of my efforts were worth it.* (Secondary biology and chemistry teacher)

Together, these challenges must be addressed to ensure smooth transitions and successful online teaching experiences. Teachers must be equipped with knowledge and skills, as well as heightened self-efficacy and opportunities to change their mindset as they transition to online teaching. The time that teachers invested in learning how to use technological tools or searching for resources distracted from instructional time and made the goal of assessment of learning difficult. This echoes the importance of teacher training and in-service PD focusing on online teaching tools so that teachers learn how to utilize the necessary technological skills (Davis et al., 2007; Jung, 2005; Smith et al., 2016; Stoetzel & Shedrow, 2020). Developing staff capacity to work more effectively in online environments and considering their efficacy will help them attain the desired outcomes when the use of online technological tools becomes mandatory.

## Conclusions

Integrating technology into the learning environment is a complex process and further exacerbated by the pandemic. On a positive note, the study reported several successes witnessed by STEM teachers that parallel those reported in the literature such as providing tailored feedback to students (Hung & Jeng, 2013), student engagement (Dumford & Miller, 2018), and learner agency and autonomy (De Paepe et al., 2018). This study further emphasizes the positive impact on teacher outcomes such as teacher professional learning and their enhanced utilization of digital tools. These are successes that need to be capitalized on as they can positively impact teaching and learning.

On the other hand, the overall results of the study highlight participants' general dissatisfaction with and negative

attitudes toward online teaching during the COVID-19 pandemic. Reasons for participants' views are situated in lack of readiness and lack of required technological skills, which impacted their self-efficacy. Moreover, teachers faced many challenges throughout the online teaching process that certainly influenced their attitudes. The major challenges included professional time constraints, locating appropriate digital resources and accompanying pedagogy, fostering and maintaining student engagement, the lack of support and PD, navigating technological challenges, and the lack of direction from leadership. These aforementioned challenges exacerbated student-related challenges (e.g., De Paepe et al., 2018) and teacher-related challenges (e.g., Davis et al., 2007) associated with online teaching.

Particular tensions inherent in technology-focused activities are teachers' self-efficacy and beliefs about technology, as these are strong predictors of technological integration in practice. In order to increase teachers' self-efficacy and beliefs about the value of technology, they should be exposed to and experience ample opportunities to plan and select appropriate pedagogical practices in STEM. Schools should provide teachers with relevant resources and support and encourage them to interact with colleagues to enhance their confidence in technology integration. This reiterates the importance of communities of practice (Wenger, 1998) that can serve as a repository for teachers to share their expertise and resources. Hence, teachers can build relationships that enable them to learn from each other in preparation for nimble adjustments, such as those necessitated in transitioning to online teaching during the pandemic.

Other main challenges including the lack of PD and access to high-quality teaching resources can be addressed by leadership at the school board and government levels, as elucidated by Lowenthal et al. (2018) and Zhang and Lin (2020). Professional development initiatives that enhance teachers' TPACK as well as their understanding of the relationship between the affordances of a range of technological applications and detailed knowledge of STEM concepts, processes, and skills (DeCoito, 2016) are warranted. Moreover, teacher education can target opportunities for incorporating technology effectively into pedagogical frameworks. It is apparent that opportunities exist, which are catalytic for exploring new tools and processes to reinforce the alignment of technology and pedagogy in teaching and learning. For example, opportunities to develop curriculum that explicitly and systematically include technological integration can be tackled by in-service and preservice teachers so as to avoid future challenges related to online teaching.

TPACK, self-efficacy, communities of practice, curriculum, and mindsets are a few factors that warrant attention in terms of PD. Decision-makers must address the gaps identified in this study, given we are in the second phase of online

teaching. Undeniably, teachers will continue to face several challenges, but key questions must be attended to in order to attain the highest possible quality in online education.

## Limitations

Several limitations affected the results of this study. Yet, the unique circumstances during the COVID-19 pandemic necessitated certain measures. For example, the authors are aware of the limitation due to the self-reported biases by teachers and due to the lack of additional data sources/triangulation. Yet, interviewing and/or observing classrooms in May–June 2020 (the fourth and fifth months of the pandemic) were extremely difficult due to the lack of teachers' availability and logistical reasons. Furthermore, the lack of a control group to compare the findings of this study was also an unavoidable limitation as all schools in the location were subject to the same ERT regulations. Yet, the authors believe that the importance of collecting timely data during and right after the academic year ended outweigh those limitations. The collection of both quantitative and qualitative data from a relatively large sample in unprecedented conditions shall suffice to enhance data trustworthiness and validity. Future research may address these limitations and provide follow-up research detailing our findings.

## Implications and Further Research

This research is instrumental for providing a landscape of challenges, successes, gaps, and barriers encountered by teachers and students as they migrated to online teaching during a global pandemic. The outcome includes various recommendations to support teachers, students, and parents as we navigate the coming years. Namely, this research advances knowledge about transitions to online teaching at the K-12 levels. Moreover, it informs government, policymakers, and school administrators about the successes and challenges associated with online teaching. Findings from this study call for empowering teachers and revolutionizing their practices to ensure equitable and high-quality education for all students. They also provide an opportunity for assessing and improving teacher education programs. In addition, policymakers, curriculum developers, and school administrators must consider enhanced PD opportunities to enhance teachers' digital expertise and TPACK frameworks, engage in the creation of a repository of digitally based curriculum materials, and identify digital opportunities for learning, innovation, and inclusion. Ensuring that teachers are well equipped to teach in a virtual environment would result in more accessible and equitable education for their students as we navigate moving forward.

Findings are being shared with the education community through seminars and working groups. Our hope is that our findings provide teachers with an opportunity to reflect on and assess their current practices and explore other teachers' practices. Furthermore, due to its timely and pressing nature, the study is important as it documents teachers' experiences during the first year of the COVID-19 pandemic. Accordingly, it is important to show the successes and challenges experienced so that educational systems are better prepared for similar situations in the future.

Future research can explore teachers' online pedagogy in various Canadian provinces, especially teachers in the Canadian territories, home to Indigenous populations. Moreover, we recommend that similar research studies explore student perspectives to obtain learners' views of and attitudes toward online teaching and learning. Finally, we need to investigate the reported challenges more thoroughly and explore how they can be addressed through PD programs, as well as more robust preparation in teacher education.

**Availability of Data and Materials** Raw data is available for transparency purposes.

## Declarations

**Ethics Approval** The research has acquired ethical approval. The manuscript has not been submitted to more than one journal for simultaneous consideration. The submitted work is original and has not been published elsewhere.

**Consent to Participate** Informed consent was obtained from all individual participants included in the study. The authors affirm that human research participants provided informed consent for the publication of direct quotes.

**Competing Interests** The authors declare no competing interests.

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