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A Disorienting Dilemma: Teaching and Learning in Technology Education During a Time of Crisis

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Abstract The way individuals interpret and reinterpret their experience is central to meaning-making and impacts teaching and learning. Grounded in Mezirow's transformative learning theory, this research explores whether pandemic-related emergency remote teaching manifested as a "disorienting dilemma" for technology educators. Teachers negotiated curricular outcomes between physical aspects of making and doing, as well as creative problem solving through design, resulting in a pandemic transformed pedagogy. Thematic analysis revealed that making and doing was severely challenged due to decreased communication, student motivation, and engagement. However, most concerning to educators was the heightened disparity in equity and access in their most vulnerable and at-risk students. In conditions of fear and trauma, little is known about the impact a chaotic way of being has on learners and educators. While we cannot predict what the "new normal" will look like for schools, and what the long-term effects of emergency remote teaching will be, our research demonstrates that the disorienting dilemma COVID-19 presents will continue to shape the pandemic transformed pedagogy of technology educators.

Résumé La manière dont les individus interprètent et renouvellent le sens de leur expérience est fondamentale au processus de recherche de significations et cela a des incidences sur l'enseignement et l'apprentissage. Ancrée dans la théorie de l'apprentissage transformationnel de Mezirow, cette étude vise à déterminer si l'enseignement à distance en tant que mesure d'urgence liée à la pandémie a causé un « dilemme déstabilisant » pour les formateurs en technologie. Les enseignants ont négocié des résultats d'apprentissage situés entre certains aspects physiques du « faire et mettre en pratique » et ont adopté une approche créative dans la résolution de problèmes par réflexion conceptuelle, ce qui a donné lieu à une pédagogie transformée par la pandémie. L'analyse thématique a démontré que le « faire et mettre en

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pratique» a été grandement éprouvé par la diminution dans les communications, la baisse de motivation des étudiants ainsi que de leur engagement. Toutefois, le plus inquiétant pour les enseignants, c'est la disparité grandissante en ce qui a trait aux questions d'équité et d'accès qui touchent leurs étudiants les plus vulnérables et les plus à risque. L'on connait bien peu de choses sur les conséquences d'une façon d'être qui est chaotique sur les apprenants et les enseignants évoluant dans des conditions qui favorisent la peur et le traumatisme. Bien que nous ne puissions pas prédire en quoi consistera la «nouvelle normalité» dans les écoles ni quels seront les effets à long terme de l'enseignement à distance comme mesure d'urgence, notre étude montre que le dilemme déstabilisant que la COVID-19 nous apporte continuera de façonner la pédagogie transformée par la pandémie pour les formateurs en technologie.

Introduction

Central to meaning-making and learning is how individuals interpret and reinterpret their experience, especially during times of crisis. Transformative learning (Mezirow, 1991, 1995, 2000, 2009) is a dominant theory in adult learning that has considerable support in the empirical literature (Christie et al., 2015; Taylor, 2007, 2008; Taylor & Snyder, 2012). Transformative learning theory (Mezirow, 1991) describes how adult learners make sense of their world, how social structures influence the way they interpret their experience, and how learners change as a result (Christie et al., 2015; Hoggan, 2016). Every individual has a particular view of the world that is usually based on a set of paradigms that derive from their upbringing, life experience, culture, and education (Christie et al., 2015; Tabak & Weinstock, 2005). Individuals often have difficulty changing because their worldviews become unconscious frames of reference or constructed "habits of mind", which has been clearly illustrated throughout the COVID-19 pandemic (Braund, 2021). Thus, for perspective transformation to occur, reflection needs to be triggered through a "disorienting dilemma".

Disorienting dilemmas often challenge the validity of one's values and the assumptions that underpin them. However, designing a disorienting dilemma that prompts a change in attitudes, beliefs, and values is not explicitly presented within the theory and is the subject of ongoing research (Christie et al., 2015; Mälkki, 2012). A disorienting dilemma originating from a life crisis can also trigger a change in perspective (Mälkki, 2012). The traumatic severity of the disorienting dilemma is a factor in establishing the probability of a perspective transformation (Mezirow, 1991). A life crisis, such as the COVID-19 pandemic, places people in an involuntary chaotic situation that forces a change in ontology where individuals experience a transformation in their being in the world and their forms of relatedness (Lange, 2004). In conditions of fear and trauma, little is known about the impact this chaotic way of being has on learners and educators (John, 2016). This article adds to the evidence in this area by reporting on and exploring the disorienting dilemma of the early months of the pandemic, a time of extraordinary global fear and trauma, and the impact this had on secondary technology education (TE) teachers during their transition to emergency remote teaching (Hodges et al., 2020). Next, we provide a brief overview of transformative learning theory to situate this research.

Transformative Learning

Mezirow's theory of transformative learning (1981, 1991, 1995, 2000, 2009) argues that every individual has a particular view of the world (Christie et al., 2015). This worldview may or may not be well articulated but is usually deeply rooted in an individual's upbringing, life experience, the culture that

surrounds them, and their education. The theory involves analyzing "the psycho-cultural process of making meaning, the nature of meaning structures and how they are transformed through reflection, rational discourse, and emancipatory action" (Mezirow, 1995, p. 39). One of Mezirow's central claims is that individuals have difficulty changing because their world views become habits of mind or unconscious and often ingrained ways of viewing and interpreting situations and contexts. These developed habits of mind, or ontological frames, should be considered to understand how, what, and why adults learn.

The research presented in this article focuses on examining the professional impact of the COVID-19 pandemic on secondary TE teachers through the lens of transformative learning theory. Mezirow (1991) discusses two paths through which perspective transformation occurs: sudden insight and incremental change in insight over time. The latter is more common and can occur as we age or through education, akin to Freire's "conscientisation" (Freire, 1963; Montero, 2014). The dynamics of perspective change central to transformative learning theory include the following:

> (1) a disorienting dilemma; (2) self-examination; (3) a critical assessment of a personally internalised role; (4) relating one's discontent to similar experiences of others—recognizing that one's problem is shared; (5) exploring options for new ways of acting; (6) building competence and self-confidence (self-efficacy) in new roles; (7) planning a course of action; (8) acquiring knowledge and skills for implementing one's plans; (9) provisional efforts to try new roles and assess feedback; and (10) a reintegration into a society based on conditions dictated by the new perspective (Mezirow, 1981, p. 7).

For modern perspectives on transformative learning, see Christie et al. (2015), Eschenbacher and Fleming (2020), Hoggan (2016), and Taylor and Snyder (2012).

The Pandemic Transformed Pedagogy Project

When the WHO Director-General declared SARS-CoV-2, commonly known as COVID-19, a pandemic (WHO, 2020), K-12 school systems worldwide responded with an almost immediate suspension of in-class instruction. In British Columbia, Canada, the Minister of Education directed all schools to immediately suspend in-class instruction (Fleming, 2020), forcing over 500,000 students and 44,000 teachers to shift to emergency remote teaching (ERT; Hyslop, 2020a, 2020b). ERT involves a "temporary shift of instructional delivery to an alternate delivery format due to crisis circumstances" (Hodges et al., 2020). Teaching in online, blended, or hybrid learning modalities requires a significant reimagining and re-design of the pedagogy educators use (Jonassen, 2006; Kanuka, 2006). As a result, the shift to ERT necessarily impacted the curricula. For educators, the delivery of content required a change in actions, judgement, and selection of teaching strategies (Jonassen & Land, 2014), leaving many practicing classroom teachers unprepared.

The Pandemic Transformed Pedagogy Project (PTP) began by capturing the needs of secondary TE teachers in British Columbia, Canada, during the pandemic. This project's overall aim is to find ways to empower secondary technology educators with evidence-based learning designs that they can use with their students that are both flexible in their delivery modality yet meet prescribed learning outcomes (Code et al., 2020; Forde et al., 2020). To understand why the pandemic declaration and the switch to ERT was a disorienting dilemma for technology teachers in particular, we begin with an outline of the ontological frame that dominates TE curriculum and pedagogy.

Technology Education as an Ontological Frame

TE has its roots in design: the creating, making, and doing aspects of human activity (Archer, 1979) or the "head, heart, and hands model" of transformative learning (Orr, 1992; Singleton, 2015). The head,

heart, and hands model is an integrated approach to developing a transformative experience of learning that relates the cognitive domain (head) to critical reflection, the affective domain (heart) to relational knowing, and the psychomotor domain (hands) to engagement (Singleton, 2015). TE and designerly ways of knowing (DWOK; Cross, 1982) are a distinct epistemology independent from scientific and scholarly understandings (Aikenhead, 2021). DWOK helps individuals develop constructive thinking, iconic three-dimensional models of cognition, and a wide range of non-verbal thought and communication skills (Cross, 1982). In the context of this research, TE focuses on developing DWOK related to both digital and physical technologies.

With the advent of constructivist and constructionist learning theories, and low-cost technologies through the maker movement, TE now enjoys wider acceptance with more effective implementation in schools (Barak, 2018; Bilkstein, 2018). Across international program outcomes, TE has typically fallen under the umbrella of curricula in design and technology, career and TE, industrial design, or technology and engineering education (Brown & Brown, 2010). In British Columbia, TE is situated within the *Applied Design, Skills, and Technologies* (ADST) curriculum and:

> Involves students in the design and fabrication of products and/or repair and maintenance services using a variety of materials, methods, technologies, and tools…to develop their ability to shape and change materials in the physical world to meet human needs…Using creative and critical thinking, students have the opportunity to work collaboratively to address real-world challenges by exploring materials, using tools and equipment, designing and building, developing processes, and communicating the merits of their work (BCMOE, 2018).

At the secondary level, students in TE engage in a period of user-centered design research and empathetic observation to understand various design opportunities (BCMOE, 2018). Central to the pedagogy in TE is specific, hands-on, experiential learning with multiple design tools and physical equipment. Thus, we hypothesised that the disruption caused by the pandemic declaration and subsequent public health measures would affect the pedagogy of TE teachers and, by association, their students.

Research Questions

The primary aim of this exploratory research is to examine how the pandemic declaration and the switch to ERT affected TE teachers and how this was a particularly disorienting dilemma. Specifically, we examined the following research questions.

RQ1. How has the switch to ERT affected the pedagogy of TE teachers?
RQ2. How has the switch to ERT affected TE teachers' interactions with students?
RQ3. Has the pandemic and forced switch to ERT represent a disorienting dilemma for TE teachers?

Research Design and Methodology

Data Collection

Following research ethics approval from our institution's research ethics board, the survey was delivered via our local installation of Qualtrics (2020). All participants were presented with written instructions to indicate their consent to participate before the online survey. We exported the data to SPSS (IBM Corp, 2020) and NVivo (QSR, 2020). Following guidelines outlined by Braun and Clark (2006, 2014), a thematic analysis was conducted whereby two authors (KF, RR) familiarised themselves with the responses,

generated initial codes, and organised the data into overarching key themes and subthemes. This process was data-driven, inductive, and themes were identified and selected by researchers in alignment with our research questions. The authors (KF, RR) iteratively compared their analyses and coding and reached a consensus. Details about inter-rater reliability are discussed in the "Thematic Analysis" section.

Participants

The data presented comes from a snowball and convenience sampling of TE teachers in British Columbia, Canada. The research team recruited participants through their professional organisation's closed Facebook group between 8 and 10 weeks after the pandemic declaration. We recruited 44 secondary specialist TE teachers (excluding two due to missing data). Participants ($N = 42$) included 76% male ($n = 32$), 22% female ($n = 9$), and 2% undisclosed ($n = 1$), with 24% ($n = 10$) under the age of 30, 38% ($n = 16$) between 30 and 40, 26% ($n = 11$) between 40 and 50, and 12% ($n = 5$) over the age of 50. Teaching experience ranged from 1 to 38 years with a mean of 11 ($SD = 9.8$).

Survey

Demographics

Demographic information collected from each participant included the following: age, gender, number of years taught, teaching modality (face-to-face, hybrid, online), and courses they were teaching that they transitioned to ERT. Course subject areas include woodwork (69%), technology explorations (48%), drafting (36%), metalwork (31%), furniture and cabinetry (29%), electronics and robotics (19%), art metal and jewelry (19%), power technology (12%), machining and welding (12%), and automotive technology (12%).

Selected and Open Response Questions

In addition to the demographic survey items, we developed a set of selected-response and open-ended questions to precisely capture the characteristics of the classroom context that changed because of the COVID-19 pandemic. The selected-response questions aimed at capturing general class characteristics as follows:

Please answer the following based on your experience before COVID-19 remote learning:

- What style of teaching did you do? (face-to-face, online, blended).
- How long (on average) were your classes?
- How were you contacting your students (check all that apply)?
- How often did you interact with your students?
- What percentage of your class involves students using tools/equipment/materials?

Please answer the following questions based on your teaching experience during COVID-19 remote learning.

- What style of teaching are you doing now?
- How long on average are your classes now?
- How are you contacting your students (check all that apply)?
- How often are you interacting with your enrolled students?

The open-ended questions to capture pre- and post-pandemic teaching strategies, opportunities, and challenges are as follows.

- Describe a hands-on assignment you do with your students?
- What would you say is the most challenging part of teaching face to face in a classroom?
- Think back to the hands-on assignment you described earlier. Can you do this assignment through the remote teaching format? Why or why not?
- What is the most challenging part of remote teaching?
- List any issues you or your students have had with the technology involved in the switch to remote teaching?
- What are your concerns about the future of teaching tech ed remotely?

Results

Descriptive Statistics

An analysis of the selected response questions reveals a significant shift in the modality of instruction, with the majority ($n = 40$) teaching face-to-face before the pandemic declaration, and all TE teachers ($n = 42$) transitioning completely to remote online instruction during ERT.

Upon transition to ERT, teachers were given access to a suite of technologies and digital learning tools through the Ministry, although support for these tools was uneven across districts, likely because of demand and resourcing issues. Further, the tools made available readily supported pedagogies not necessarily aligned with the needs of many teachers, especially those working in hands-on project-based contexts (for a list, see Code et al., 2020). There was a significant reduction in average class times, with most teachers ($n = 40$) moving from 60–120-min periods (that included hands-on time with tools and equipment) to 30–40-min synchronous sessions ($n = 38$).

As a result of the modality change, communication methods between teachers and students also changed. Figure 1 highlights the most common communication methods between teachers and students before the pandemic and how they changed due to ERT. Most communication with students before ERT was face-to-face ($n = 42$), with some email to support ($n = 23$). During ERT teachers communicated most often through email ($n = 39$), with some video chat ($n = 26$) and phone calls ($n = 25$). Most notably, in alignment with the public health orders, there was no face-to-face communication.

In addition, we asked teachers how often they interacted with their students (i.e., having back and forth conversations). Figure 2 illustrates how this interaction changed. TE teachers indicated that they

Fig. 1 Communication with Students Beforeand During ERT

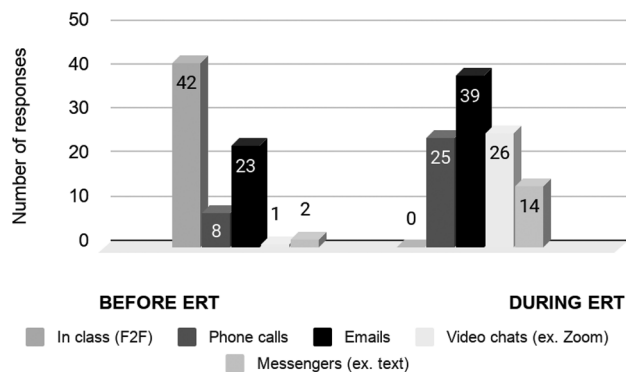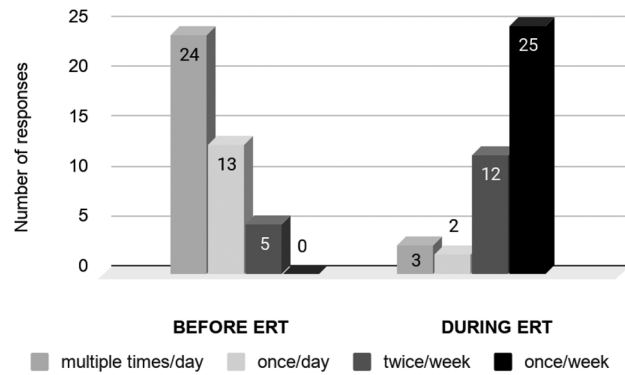176

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Fig. 2 Interaction Frequency BetweenTeachers and Students Before and During ERT

interacted with their students daily ($n=13$) and several times per day ($n=24$) before ERT; upon switching teaching modalities, this interaction changed to once ($n=25$) or twice ($n=12$) a week.

The overall shift in frequency of interaction has become synonymous with ERT as instructional delivery became and, at the time of authoring this article, continues to be altered during the ongoing crisis in education that the pandemic has created (Hodges et al., 2020). A thematic analysis of the open-ended questions clarifies how the drastic changes illustrated in this section affected teachers.

Thematic Analysis

A thematic analysis was conducted on each open-ended response to identify patterns and themes in the participants' responses (Braun & Clarke, 2006). The research team collectively identified the relevant themes and agreed upon item placement, revealing the several key themes and subthemes illustrated below. Each item was coded independently by two members of the research team. Inter-rater reliability was determined using Cohen's kappa (κ). For reference, in relation to a kappa between 0 and 1: 0 is agreement equivalent to chance; slight agreement is in between 0.1 and 0.2; fair agreement is between 0.21 and 0.40; moderate agreement is between 0.41 and 0.60, substantial agreement is between 0.61 and 0.80; and near-perfect agreement is above 0.81 (McHugh, 2012). For our research, kappa agreed for themes *teaching challenges before ERT* ($\kappa=0.75$, $p<0.0005$), *teaching challenges during ERT* ($\kappa=0.61$, $p<0.0005$), and *technology issues during ERT* ($\kappa=0.70$, $p<0.0005$). Each key theme and subtheme are presented in Tables 1–3. Direct quotes from participants have been edited only for spelling and grammar.

Teaching Challenges Before ERT

The study participants identified typical classroom challenges before ERT that we organised into the following themes (Table 1): *access, classroom management, motivation,* and *learning design*.

Access   In this context, as indicated in Table 1, *access* means access to tools and equipment, both hand tools and machinery, and digital technologies necessary for learning. Before ERT, teachers identified existing challenges around accessing modern tools, equipment, and technologies essential for a twenty-first century classroom. Some teachers described "having no tools or books available for myself or students" (Participant 1) and challenges with "getting equipment modernized" (Participant 29) or generally "access to equipment" (Participant 34).

Classroom Management   Classroom management is "the actions teachers take to create an environment that supports and facilitates both academic and social-emotional learning" (Evertson & Weinstein,

Table 1 Key themes of teacher comments for teaching challenges before ERT

Teaching challenges before ERT

Category label	Criteria	No.[a]	%[b]
Access	Access to digital technologies	6	8.82%
Technology		1	1.47%
Tools and equipment	Access to tools and equipment	5	7.35%
Classroom management		18	26.47%
Behavioural Issues	Behavioural issues, challenges with focus or attention	5	7.35%
Distractions	Outside distractions (ex. smartphones)	4	5.88%
Safety	Safety outcomes in the curriculum concerning the use of tools and equipment	9	13.24%
Motivation		19	27.94%
Absences	Absences, missing class, poor attendance	5	7.35%
Student impatience	Students not exploring learning on their own and expecting teachers to do more	1	1.47%
Engagement	Teacher and student engagement	10	14.71%
Self-motivation	Students' initiative towards their learning	3	4.41%
Learning design		25	36.76%
Class size and composition	Students enrolled (many students to one teacher), varied grade levels and abilities in one class	19	27.94%
ELL students	Non-native English speakers challenges with written or verbal instructions	1	1.47%
Non-traditional settings	Outdoor classes	1	1.47%
Prep-time	Time to prep for class	1	1.47%
Previous education	Students limited previous education in subjects intersecting with technology education	3	4.41%
		68	100%

[a]Number of comments coded in this category.

[b]Percentage of comments coded in this category.

2006, p. 4). The participants in this study identified: *behavioural issues, distractions,* and *safety* as their primary classroom management challenges. Teachers described how students were often distracted by their smartphones and that larger class sizes were challenging as they had to "make sure all students are safe" (Participant 22) in addition to "trying to keep an eye on everyone using machines" (Participant 6).

Motivation   As demonstrated by engagement with a subject, student motivation emphasises the students' interest and perceived value of a topic (Lazowski & Hulleman, 2016; Pintrich, 2003). Teachers described absences, student impatience, self-motivation, and overall engagement issues. While some students had "bad attendance records" (Participant 41), others were not self-motivated or asked for answers without thinking about solutions themselves. Multiple teachers addressed the challenges of keeping students engaged and explained that they spent considerable time encouraging or winning over students:

> Becoming adept at 'winning over' some of these students really helps. For example, students that skip many of their [other] classes will consistently show up to mine, but it's a challenge every time. (Participant 38).

Learning Design   The learning design of a classroom guides the development of practices based on the needs of students, including modes of instruction (Lieberman et al., 2008). Factors affecting the learning design included *class size and composition, ELL students, non-traditional settings, prep-time,* and *previous education* (Table 1). Many teachers expressed concern with the student–teacher ratio, indicating that there was "not enough of me to go around" (Participant 6). One teacher explained:

> There are challenges to a class size of 30 [who are] at all stages of learning. For example, in woodwork, electronics, and drafting, you will see grades 9, 10, 11 and 12 in one class. That [means] a minimum of 4 different courses … being taught within that one-time slot. (Participant 20).

And another teacher stated that:

> In larger classes, splitting my time among students evenly to try and maximize learning during shop time is the most challenging part, especially during independent projects. (Less motivated groups are easier to cover. But my classes tend to have high engagement levels). The independent projects are more taxing on me mentally, but they offer students significant personal achievement. (Participant 38).

In other challenges to the learning design, teachers noted that further consideration to the additional needs of ELL students is necessary, especially for safety, to ensure that "verbal or written instructions are understood" (Participant 18). Further, ongoing challenges in TE involve student recall and integration of other intersecting competencies in subject areas such as math, reading, and writing.

Teaching Challenges During ERT

Teachers found that while there were typical classroom issues before ERT, these issues became amplified during the pandemic. Specifically, as indicated in Table 2, key themes include challenges with *curriculum delivery, equity and access, motivation,* and *policy.*

Curriculum Delivery   In the ADST BC curriculum, student competency refers to the skills, processes, behaviours, and habits of mind that learners use (BCMOE, 2018b; Gervais, 2016). Specifically, the ADST curriculum aims to foster:

Table 2 Key themes of teacher comments for challenges to teaching during ERT

Challenges to teaching during ERT

Category label	Criteria	No.[a]	%[b]
Curriculum delivery		27	37.50%
Assessment	Assignments or projects (as assigned by the teacher and be completed by students)	12	16.67%
Topics	Types of topics in addition to competency related to technology education elective courses	15	20.83%
Equity and access		15	20.83%
Access	Access to tools and technology	9	12.50%
Equity	Quality of being fair and impartial	6	8.33%
Motivation		29	40.28%
Engagement	Teacher and student engagement	21	29.17%
Interaction	Teacher and student interaction (communication)	8	11.11%
Policy	Administrative guidance issues	1	1.39%
		72	100%

[a]Number of comments coded in this category.

[b]Percentage of comments coded in this category.

> The development of future problem solvers, innovators, service providers, and skilled citizens who can contribute to addressing challenges in our world not … yet anticipated with processes and technologies not imagined [to] improve their lives, the lives of others, and the environment. (BCMOE, 2018b).

Many of the courses within TE rely heavily on hands-on activities and projects. During the earlier stages of the pandemic, teachers expressed concerns with teaching specialised TE topics remotely and with assessment practices. Teachers detailed the considerable challenges of transforming their hands-on lessons and assignments to online remote delivery and the hours spent finding "resources, materials of value, and compiling them into a satisfying format" (Participant 16). Many described how TE classes are particularly ill-suited to the online remote format. For example, one teacher explained:

> Many of the reasons for signing up for a Tech. Ed. class (hands-on work, a physical project to take home, the teacher) are not the same or entirely missing from online learning. (Participant 2).

Another teacher stated that online work "does not mirror the intentions of the curriculum" (Participant 23), which was further complicated by students not being able to complete assignments because of either access issues or motivation.

Equity and Access TE teachers reflected on students' access to materials typically provided within classroom settings before ERT, describing how their students could not "use tools and software they were using before" (Participant 15). And most notably that "not all students have access to the same tools or materials at home" (Participant 18). These issues underscored a more significant problem of socioeconomic disparity, as some students who live in "rural or poor areas" (Participant 1) are more seriously impacted:

> This situation is magnifying inequities between families in my community. (Participant 12).
> The infrastructure needs to be improved to support rural students without Internet access. (Participant 27).

Motivation   Several TE teachers stated that student engagement was the most challenging aspect of ERT, pointing out that they had low "buy-in", explaining that "a lot of students have access but aren't participating" (Participant 8). Further, teachers found it more challenging to connect and interact with their students remotely. For example, when students often declined to communicate by ignoring email or messages, teachers were frustrated and found it challenging to provide one-on-one support. Some TE teachers believed that low engagement levels were seen because students "signed up for a skills course and are now getting a knowledge course" (Participant 16). Another teacher explained this dispiriting consequence of ERT:

> The Tech. Ed. shops are a haven for MANY kids we work within schools. They are already having trouble connecting in academic classes. Now everything is online … so they are either doing their best to keep up in … academic[s] or … or [are] not engaged at all. (Participant 38)

Further complicating matters, policymakers indicated that students who were "on track" would be promoted to the next grade level. When the Minister of Education suspended all classroom instructions, he stated that "schools will implement various measures to ensure continued learning for students" (Fleming, 2020). However, within the same letter, the Minister, also stated that "Every student will receive a final mark, and all students on track to move to the next grade will do so in the fall" (Fleming, 2020). Although the Minister's decision was made compassionately, teachers observed that it ended up diminishing motivation: "Since the government announced that students would be promoted, there is little incentive to demonstrate any new learning" (Participant 4). Another teacher explained the consequences of this announcement in more detail, explaining:

> All students know that their mark cannot go down, so unless they are intrinsically motivated and have a stable home life AND consistent access to technology, work completed will be a fraction of the quality completed in schools. I believe this applies to all classes in some regards, but in Tech. Ed. it is particularly challenging due to the lesser importance society in general places on skilled labour, trades, and technician work. (Participant 16)

Policy   Building on the previous theme, as K-12 teachers adapted to these extenuating circumstances, many sought further guidance from their administration and the Ministry of Education. As one teacher stated:

> The inconsistency of expectations. With no specific guidance and directive from admin and the school board, teachers are using different platforms to connect with students and parents; classes are being scheduled over one another, the lack of understanding [of] "attendance" and participation requirements for students and the general prioritizing of academic courses taking precedence over electives. My specific admin has advised against any activities that use tools of any kind for fear of any liability issues. (Participant 20)

Technology Issues During ERT

Topics that emerged around using technology as a mediator of teaching and learning for TE teachers during ERT include *communication, curriculum, digital literacy, equity and access,* and *outside distractions* (Table 3).

Table 3 Key themes of teacher comments for technology concerns during ERT

Technology concerns during ERT			
Category label	Criteria	No.[a]	%[b]
Communication	Communication or correspondence between teacher and student	2	2.30%
Curriculum		6	6.90%
Assessment	Assignments or projects (as assigned by the teacher and should be completed by students)	2	2.30%
Topics	Types of topics in addition to competency related to technology education elective courses	4	4.60%
Digital literacy	Understanding technology (devices and software)	6	6.90%
Equity and access		68	78.16%
Devices and materials	Access to devices and materials (e.g. computers, tools, etc.)	26	29.89%
Internet	Access to the Internet (Wi-Fi, etc.)	16	18.39%
Software	Access to software	11	12.64%
Equity	Quality of being fair and impartial	15	17.24%
Outside distractions	Outside distractions from school (ex. work, waking up, too many other courses, etc.)	3	3.44%
No issues	No technology issues	2	2.30%
		87	100%

[a]Number of comments coded in this category.

[b]Percentage of comments coded in this category.

Communication   Teachers reported a significant shift in communication methods between teachers and students, as illustrated in Figs. 4 and 5, where teachers struggled to contact some of their students.

> I have quite a few students who I have not corresponded with at all, or it is less than once per week. Some students do not have access to technology at home, or what they have does not work with the platforms that I am using. Some students also do not understand how to work certain types of software or files. We have also all had it that when a kid hands something in, we look at it and say to the kid; do that again, or what about this? or finish this question, think about it this way… [It is] much more difficult when they email it to you, and you look at it hours later or even the next day. (Participant 24)

Curriculum   Building upon the curricular challenges identified in the last section, teachers indicated that delivery issues were amplified due to technology challenges. Although TE has more hands-on physical projects, teachers said that students were not completing tasks even when they re-designed their lessons towards more digital projects using technologies, such as YouTube, Zoom, or Microsoft Teams. As illustrated in the previous section under *motivation*, many noted that the policy changes were critical.

Digital Literacy   Digital literacy involves "technical, cognitive, and sociological skills to perform tasks and solve problems in digital environments" (Eshet, 2004, p. 93). Teachers described students' issues with "remember[ing] passwords and sign-ins. For some, computer technology is not their thing, and it's a big learning curve for them" (Participant 6). For others, they had students unfamiliar with basic computer literacy skills like "copying and pasting links, how to properly use search engines, etc." (Participant 13).

Equity and Access   Teachers identified considerable equity and access to technology problems, including *devices, materials, Internet,* and *software,* compounding the issues above. Most teachers made comments about the limited access to devices and materials and that "many have no access or time as families are trying to share devices or do not have reliable" (Participant 23) or that there were shared devices within one household, with some students having no access at all. One teacher said,

> Some students have one computer for up to 7 … in a household. Some don't have access to any tools at all. (Participant 5)

Another teacher described the challenges they faced:

> My personal laptop died two days ago, and I had to pay to have it repaired. I had to limp along with my iPad and iPhone to teach. I have a district computer, but the specialized software that I need doesn't work remotely. (Participant 30)

Internet connectivity and reliability further complicated issues as some teachers pointed to limited Wi-Fi in remote locations or slow Internet speeds. One teacher described how some "students [had] limited Internet data plans at home (no YouTube, Tinkercad or Zoom)" (Participant 34). Complications emerged with specialised software necessary for some TE courses such as AutoCAD and RobotC:

> There is limited access to a high-performance computer and licensed software. Many of the projects that "could be done from home" can only be completed by about 10% of my students. (Participant 2)

These issues were further amplified based on socioeconomic disparities. Many of the students were identified as having "unstable home lives" (Participant 38), and some families were not worried about school but dealing with "crisis related to food and lodging" (Participant 4).

Discussion

As discussed earlier, TE is founded primarily in creating, making, and doing aspects of human activity (Archer, 1979). Central to this approach is the head, heart, and hands model of transformative learning (Orr, 1992; Singleton, 2015), an integrated approach to developing a transformative experience of learning that relates the cognitive, affective, and psychomotor domains to the head, heart, and hands, respectively. (Singleton, 2015). Alongside this, Cross's (1982) seminal work around DWOK points to the centrality of non-verbal modes of communication in what he describes as the "third culture" of design (as distinct from numeracy and literacy). From a theoretical standpoint, Mezirow's transformative learning is supported, particularly that COVID-19 and the resulting change in living, teaching, and learning circumstances constitute a disorienting dilemma, potentially precipitating transformative learning. It is, then, no surprise that the pandemic declaration and the switch to ERT profoundly affected TE teachers. We will now turn to a discussion of our findings and address each of our research questions.

How Has the Switch to ERT Affected the Pedagogy of TE Teachers?

Curriculum Prescribed Competencies Are a Casualty

In the context of this research, the subject matter TE teachers focused on was deeply embedded in developing DWOK (Cross, 1982) related to *digital and physical technologies*. Since the TE teachers were following curriculum that was meant to mediate, or negotiate, between the physical aspects of making and doing, in addition to creative problem solving using digital media, the biggest challenge they faced was being removed from the equipment and tools in their classrooms. Our research demonstrates that TE teachers did their best to adapt their pedagogy to meet student needs during these extenuating circumstances. For example, in an electronics class, a teacher could use of Tinkercad, a free-of-charge SD modelling program that allows users to perform basic 3D modelling and to model electronic circuitry. This could allow the teacher to introduce new material while also maintaining some continuity with what students had been learning in the classroom. Activities could include reproducing modelled renditions of project designs that students had been working on back in their classrooms as well as taking detailed measurements of their homes and living quarters and rendering these buildings and spaces using Tinkercad.

Nonetheless, some of the curricula prescribed competencies around physically making and doing became a casualty due to lack of access of certain equipment and material. For example, in the technology explorations course, one of the outcomes requires students to consider mobile devices' social, cultural, and economic impact (BCMOE, 2018). This particular outcome could be readily adapted to a technology-mediated pedagogy. However, in the same technology explorations course, students are also meant to develop metalworking skills and competencies using hand tools and power equipment (BCMOE, 2018). Given the issues with safety, equity, and access to tools and technologies, this prescribed outcome could not be achieved.

As many of our TE participants described, most TE electives are designed around the hands-on development of physical projects. As pandemic circumstances continue to shift, educators, administrators, and policymakers may wish to develop or continue blended or hybrid learning opportunities (e.g. Zitter & Hoeve, 2012; Zitter et al., 2009). TE teachers in this research expressed concerns about

the future of TE as a profession if this hybridity were to become the norm. Specifically, teachers were concerned that students that may, in regular circumstances, have been attracted to taking the elective courses offered in TE might shy away from them if the courses continue to take place online and this could, longer term, have an impact on teachers' job security. One teacher noted that a sustained period of teaching online could even exacerbate the shortage of people trained and experienced in the trades, something that is already a pressing concern in BC (CBC News, 2021). For a discussion of these findings, please see (Code et al., 2020).

Despite TE teachers recognizing that most of their students take TE courses to develop hands-on designerly competencies, several of our participants lamented that their courses are "not transfer[ring] well to online settings" (Participant 26). In contrast, others began to reflect upon and rethink aspects of their pedagogy.

Pedagogy Reimagined

Our research reinforces that teaching in online, blended, or hybrid learning modalities requires a significant reimagining and re-design of the pedagogy educators use (Jonassen, 2006; Kanuka, 2006). The shift to ERT impacted the curricula. The content TE educators taught required a change in actions, judgements, and the selection of teaching strategies (Jonassen & Land, 2014), leaving many teachers ill-equipped to deal with these new circumstances. As illustrated, TE teachers' pandemic transformed pedagogy left many outcomes behind. Particularly those connected to three-dimensional models of cognition (Cross, 1982), interrupting the integrated approach to the learning experience (head, heart, and hands) most often engaged in the TE context (Singleton, 2015).

TE teachers often spend time in class instructing students on equipment safety or performing demonstrations using various tools. Much of this work was just-in-time and often personalised to each student as they progressed according to their competency level. When the current provincial curriculum was introduced, there was an emphasis on personalised learning focusing on giving students "more opportunity to pursue their passions and interests" (BCMOE, 2015). Our participants thus spent a great deal of time developing YouTube videos that they recognise are inherently valuable in their ability to save instructional time and offer 'just-in-time' resources for students to review at their own pace. However, despite the inherent value, many participants found that developing these videos for students to view was "time-consuming and not what kids signed up for" (Participant 16).

How Has the Switch to ERT Affected TE Teachers' Interactions with Students?

Obstructed Engagement

I have quite a few students who I have not corresponded with at all, or it is less than once per week. Some students do not have access to technology at home, or what they have does not work with the platforms that I am using. (Participant 24).

Many teachers reported that, during the pandemic, there was a marked decrease in engagement from their students. Factors contributing to this were manifold, including the access challenge addressed below. However, the main demotivating factor that teachers pointed to concerned the lack of embodied experiential learning, a significant component of TE. Notably, the sentiment that the ERT experience was "not was the students signed up for" in that one of the attractions of TE is the hands-on skill-based experience that was replaced, in many cases, by far greater focus on more theoretical text-based learning. As an analogy, in the same way, that someone who signed up for in-person swimming lessons would be disappointed (and dismayed!) to learn later that the classes would take place online, TE student engagement suffered because the essential embodied component of the activity was absent. The final straw,

as it were, was the Ministry's announcement that all students would be promoted, which significantly devalued any additional effort students made in their coursework.

Undermining Equity and Access

The concomitance of equity and access for all is somewhat self-evident, as "any society committed to promoting equity must ensure that their education system…is accessible to students from the broadest spectrum" (Salami & Bassett, 2014, p. 362). Further:

> Equity is defined as providing equal opportunities for access and success … [Which] means that circumstances beyond an individual's control … should not influence a person's access…equity is not about treating everyone exactly the same but about providing interventions that promote equality of opportunity. (Salami & Bassett, 2014, p. 365)

Equity and equality of opportunity were completely undermined during the COVID-19 pandemic. It was quite apparent through the TE teachers' comments that equity and access were the most alarming limiting factors, which the overwhelming majority were concerned about, as illustrated by the following participants.

> "Some students have one computer for up to 7 … in a household. Some don't have access to any tools at all." (Participant 5)
> "Students hav[e] limited Internet data plans at home (no YouTube, Tinkercad or Zoom)." (Participant 34)

For 25 years, the term "digital divide" has been used to describe the gap between people who have access to and use the Internet and digital media and those who do not (Hoffman et al., 2000; Van Dijk, 2020). It quickly became apparent that teachers could not presume that their students had the requisite digital literacy to participate meaningfully in their coursework, an issue compounded by the inequity and lack of access to tools, devices, and connectivity critical for student success. This research clearly illustrates the magnification of the digital divide and its impact on the education students could access, a finding continues to be reported in the literature (e.g. Eschenbacher & Fleming, 2020). Moving forward, we need to consider "designing and implementing policies aiming to remove systematic differences in… education opportunities for groups and individuals who differ only in terms of their place of birth or residence, ethnic or cultural origin, gender or because of disabilities" (Salami & Bassett, 2014, p. 365).

Did the Pandemic and Forced Switch to ERT Constitute a Disorienting Dilemma for TE Teachers?

Our research presents data from a survey identifying TE teachers' perspectives of their pedagogical shift to ERT. Through the lens of Mezirow's transformative learning theory and our survey results, we argue that the pandemic and switch to ERT created a 'disorienting dilemma' for TE teachers.

On the face of it, the sudden transition to ERT was a clear case of a disorientating dilemma for K-12 teachers, given that it forced them to assess so many of the things that they, as teachers, had taken for granted. Their training and experience had not prepared them for a sudden switch to remote teaching. So much of K-12 education is structured around the bricks-and-mortar of the school environment. From classrooms, desks, locker, bells, books, and Bunsen burners, "schools" as we conceived of pre-pandemic was for everyone a *place* rather than an activity. Suddenly, "going to school" ceased to be a physical relocation for both teachers and students. Instead, the first challenge was negotiating the new conceptual

challenge that "school" was now the same as "home". Of course, this is entirely different from home-schooling. Teachers were "working from home" or, perhaps more accurately, "living at work", which was compounded by the challenges of teaching in a new modality and attempting to engage with their learners who were similarly struggling with this dislocation of the locus of learning.

In addition, teachers worried about their career prospects and were concerned that the pandemic might see enrollment in TE dropping to levels that threaten the viability of programs in schools. Teachers also struggled to establish and maintain a connection with their students and regularly taught "into the void" through MS Teams or Zoom, not knowing to what degree, or even if, their students were finding the learning experiences valuable. Uncertainty can be demoralizing for teachers and students alike: "feeling ashamed of being disoriented might be accompanied by fear, loss and (anticipatory) grief, not knowing how to cope with the current crisis" (Eschenbacher & Fleming, 2020, p. 660). Given this uncertainty, one might argue that this trauma alone constitutes an ongoing disorientating dilemma for educators.

Limitations and Future Research

There are limitations to this study. Since our research is qualitative in nature, a smaller sample size limits our ability to generalise to the whole profession. However, in the context of this research and the questions we asked, we achieved data saturation (Saunders et al., 2018) across participants. Given the area of specialisation of our participants and the ontological frame in which they work, follow-up research would benefit from semi-structured interviews to examine whether and how perspective transformations occurred. Future research should expand beyond TE into other subject areas to explore the similarities and differences in transformative learning across secondary teachers. As the pandemic has continued into a second year, longitudinal studies would be an opportune avenue of exploration. We hope our study can inform future research examining the disorienting conditions of the pandemic and whether pedagogical and systemic changes remain episodic or have more prolonged effects.

Conclusion

An educator may set out to disrupt comfortable world views held by participants as in the practice of 'ideology critique,'… [while] in other instances, the 'disorienting' is generated by an external event, such as a personal illness, the loss of a job, or cultural dislocation … The educator in these circumstances operates on the border between therapy and education, assisting learning to search for meaning, however tentative and fragile. (Sands & Tennant, 2010).

This research was conducted during the earlier stages of the "stay at home" mandate. We wanted to capture the experience and feelings of TE teachers during the particularly challenging ERT time. We highlighted the challenges TE teachers faced as they made their best attempts to offer a stable learning environment for their students while negotiating challenges around technological and socioeconomic disparity, alongside the accompanying challenges around motivation and engagement. We recognise that COVID-19 will continue to have a more significant impact on our education system. As we move through the successive waves of the pandemic, pedagogical challenges of delivering curriculum during this crisis will endure. While we cannot predict what the "new normal" will look like for schools, and what the long-term effects of ERT will be, our research demonstrates that the disorienting dilemma COVID-19 presents will continue to shape the pandemic transformed pedagogy of technology educators.

Declarations

Ethical Approval   All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest   On behalf of all authors, the corresponding author states that there is no conflict of interest.

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