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Pandemic Pedagogy: K-12 Technology and Engineering Education Under COVID-19

By Daniel P. Kelly

ABSTRACT

No single event in modern history has affected education like COVID-19. This study examines the effects of COVID-19 related modifications within technology and engineering education. Using social media, a survey was distributed among groups whose focus was technology and engineering education. This survey asked how teachers addressed COVID-19 related modifications to instruction and how they felt about instructional quality and support. The results showed that teachers are working longer hours, yet instruction is suffering due to virtual/hybrid teaching, social distancing, and sanitation concerns. Hands-on and group work has been largely limited or eliminated entirely, and many lessons have had to be heavily adapted if they are possible at all. Most concerning is an apparent deficit in morale, with a substantial number of teachers contemplating leaving the classroom if the current conditions continue. COVID-19 has wreaked havoc in nearly every facet of life in 2020, but the challenges faced in education are largely undocumented within the academic literature. It is imperative that the real-time effects of COVID-19 on teaching and learning be understood so that adjustments can be made while the nation is still affected by the pandemic and future changes to instruction to address currently developing deficits are made with a full understanding of what occurred during the crisis rather than retrospectively.

Key Words: *technology education, engineering education, COVID-19, pandemic, pedagogy*

INTRODUCTION

The COVID-19 global pandemic has left an indelible mark on K-12 education in the United States. School shutdowns, virtual and hybrid learning environments, and the need for additional safety precautions have transformed how teaching and instruction look from pre-kindergarten to graduate education. The additional stressors on students, teachers, and administrators are palpable for anyone who has any connection to an educational institution (Petillion & McNeil, 2020). Given the widespread and pervasive nature of the reactions to this pandemic, it is imperative to capture what is occurring and felt at the classroom level during real time, rather than looking historically at the phenomenon, after everything has calmed down and life has returned to "normal."

Given that technology and engineering education (TEE) has been, historically, largely represented by hands-on curricula, it is essential to understand how virtual and hybrid instructional models have impacted a discipline that is typically taught face-to-face. Additionally, TEE frequently involves collaborative and group work, which may be affected by either the need for online and virtual instruction, the restrictions placed on classroom teachers resulting from social distance requirements, or both. There is also the matter of disease transmission through contact with common materials, which makes student safety through the sanitation of common tools and parts an important aspect to understand under COVID-19 conditions to meet the guidelines recommended by the Centers for Disease Control (CDC).

It is impossible to know how long education will be directly impacted by COVID-19 or how long the effects of the 2020-2021 academic year will impact education generally and TEE specifically. Starting in March 2020, schools across the country were essentially shut down, and instruction was halted in many of those environments (Gaudiot & Kasahara, 2020). In schools where instruction was continued, it was exceptionally limited during that first spring of the pandemic. The transition into the fall of 2020 presented a plethora of instructional models across the country. Some schools were fully face-to-face, others were entirely virtual or remote, many operated under hybrid models with some students virtual and others in the classroom, and some schools even delayed opening for several weeks or months with no instruction at all. Even within these models, there are vast differences between instructional delivery methods. Some teachers taught only in one modality while other teachers taught via other modalities (i.e., one teacher was dedicated to remote students and another teacher was dedicated to face-to-face students), some teachers taught face-to-face and remote students simultaneously (hybrid), and still others taught within other models or switched between modalities depending on the

circumstances. Many have also had to quarantine themselves and teach remotely to students in the classroom and contend with frequent changes in student modalities as students were quarantined.

Designed to examine the real-world and current impact of COVID-19 on TEE courses, this study surveyed K-12 teachers to determine what changes they have made to instruction as a direct result of COVID-19. Also of interest is how teachers perceive their instructional ability, the support they receive, and how their students are faring under the ever-changing instructional environments as a direct result of COVID-19. Finally, it is important to understand the future potential impacts these changes will have and whether education will be saddled with long-term effects from the unprecedented instructional models that have been required.

RESEARCH QUESTIONS

This study sought to answer the following questions:

RQ1: What changes have technology and engineering education teachers had to make to instructional practices as a direct result of COVID-19?

RQ2: How do technology and engineering education teachers perceive changes to instructional models, classroom settings, institutional support, and student adaptation as a direct result of COVID-19?

RQ3: What is the potential long-term impact of COVID-19 related instructional changes within technology and engineering education?

To answer these questions, a survey was distributed through social media groups directly related to technology and engineering education. The survey was sent out during the first week of November 2020, and the results were collected and analyzed two weeks later.

PARTICIPANTS

At the time of collection (November 2020), 105 teachers had completed the survey, representing 32 states and one Department of Defense school with an average of 14.8 years of experience. Female teachers constituted the majority of respondents at 59.4%, with male teachers making up 39.6%. One teacher marked "prefer not to answer," and no respondents selected "other gender identity."

Survey respondents were asked which grade levels they teach. These were categorized as elementary, middle, and high school levels, with elementary representing grades Kindergarten through fifth, middle being grades six through eight, and high being grades nine through twelve. Teachers who indicated overlap were categorized as elementary/middle or middle/high based on their response, and one teacher indicated they taught all grades and were coded as K-12. Figure 1. displays the distribution of teachers across these grade levels.

Consistent with many TEE programs, the grade levels reported to be taught in this survey are skewed toward high school. For the respondents of this survey, 58.8% of teachers were at the high school level, 25.1% at the middle school level, and 16.2% teach elementary school-aged students.

SURVEY RESULTS

To address the research questions, TEE teachers were asked questions related to curriculum, instructional modality, student learning and attitudes, administrative support, working conditions, modifications to instructions and classroom safety, and challenges faced as a result of COVID-19. The results help to paint a picture of what TEE looks like under pandemic conditions. They are intended to understand how TEE teachers perceive teaching and learning during COVID-19 and provide a sense of the level of stress they currently experience.

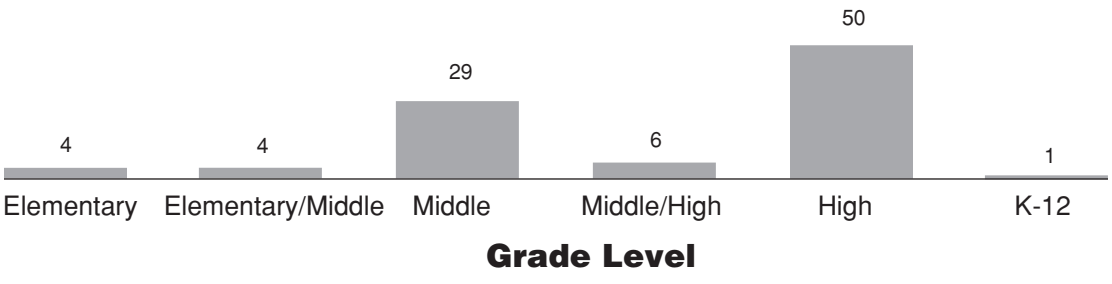

Figure 1. Grade level distribution of teachers.

Curriculum and Instructional Modality

Project Lead the Way (PLTW) represented the majority of curricula taught, with 56.3% of respondents teaching the curricula. PLTW was followed by Engineering by Design (6.3%), Teach Engineering (3.6%), and Novel Engineering (0.9%). The remaining teachers reported using self-designed, state-sanctioned, or some other modified curriculum.

Most teachers who responded to this survey (55.8%) were teaching in a hybrid instructional format with some students online (virtual/ remote). Figure 2. on page 5 displays the percentages of teachers using each modality. Teachers who selected "other" indicated that they were teaching some sections entirely face-to-face and some fully virtual, while others were contending with regular school shutdowns and switching between in-person and remote teaching. Most teachers had been teaching in the same modality from the beginning of the 2020-2021 school year until the time of this survey in November; however, 27.4% of teachers had changed modalities at some point during the year.

Most teachers reported being comfortable with the instructional modality in which they were teaching at the time of the survey, with 61.1% indicating some level of comfort and 35.8% indicating they were uncomfortable. Most teachers, 41.1%, reported being moderately comfortable with their current modality. Figure 3. displays the teacher responses at all levels of reported comfort.

Teaching and Learning

There is no doubt that teaching and learning have been affected by COVID-19. Differing and changing instructional modalities, technical issues, illness, absence, teacher and student quarantine, and a host of other issues have had an impact, but how much that instruction has been affected is still being determined. Through this survey, TEE teachers were asked, in their opinion, if they thought teaching and learning had been affected by the pandemic. Unfortunately, but expected, respondents believe that teaching and learning have been negatively impacted by COVID-19 changes and challenges to instruction, with an overwhelming proportion, 86.0%, responding negatively. Only 7.5% of teachers believe these changes have had a positive effect. Further, teachers responding that teaching and learning were negatively affected mostly indicated that the effect was moderately negative (40.0%) or extremely negative (37.5%). Figure 4. displays these results.

Contrary to how teachers perceived teaching and learning as being negatively affected, 62.8% of teachers feel that students have dealt positively with COVID-19. Most, 37.2%, indicated they felt students were handling the pandemic moderately well.

As teachers felt their students handled COVID-19 reasonably well, so too did they feel their administration dealt with the pandemic slightly well. The requests from administration related to modifications were largely viewed as being reasonable, or at least not unreasonable. Teachers' responses to administration handling of the pandemic resulted in a mean score of 3.55 out of 7 with a median score of 3, indicating that teachers viewed the administration response as slightly above neutral. The perceived reasonableness of the modifications requested had a mean response score of 3.69 of 7, with a median of 4, placing the median response as neutral.

The median scores are less valuable without context due to those teachers answering in the extremes of the scaled scores as opposed to teachers responding closer to neutral. When analyzed in terms of positive or negative belief, there was more disparity in the responses to administration handling of COVID-19 with 25.5% more teachers viewing administration response as positive, and only 5.3% more teachers indicating the requests from administrators as reasonable. Interestingly, when viewed together, the data show that the differences in perception between these two variables are primarily in those teachers who did not have strong opinions regarding these questions. Responses toward either extreme in the Likert-style scale varied by only 1.0%, whereas variance in responses in the middle of the scale averaged 9.2%. Figure 5 on page 6 displays these two variables together to demonstrate the differences in variability.

Working Conditions

Although teachers indicated that the requests from administration were slightly positive, teachers are still spending greater amounts of time at work than in previous years. The vast majority of teachers, 91.5%, indicated that they spend more time at work as a result of COVID-19 related modifications. Of those teachers spending more time at work, 58.1% responded that they worked ten or more

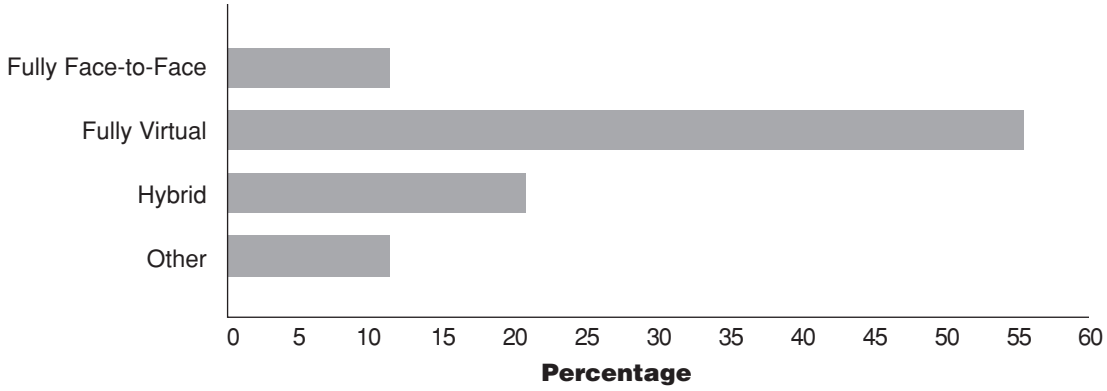

Figure 2. Percentage of teachers in each instructional modality.

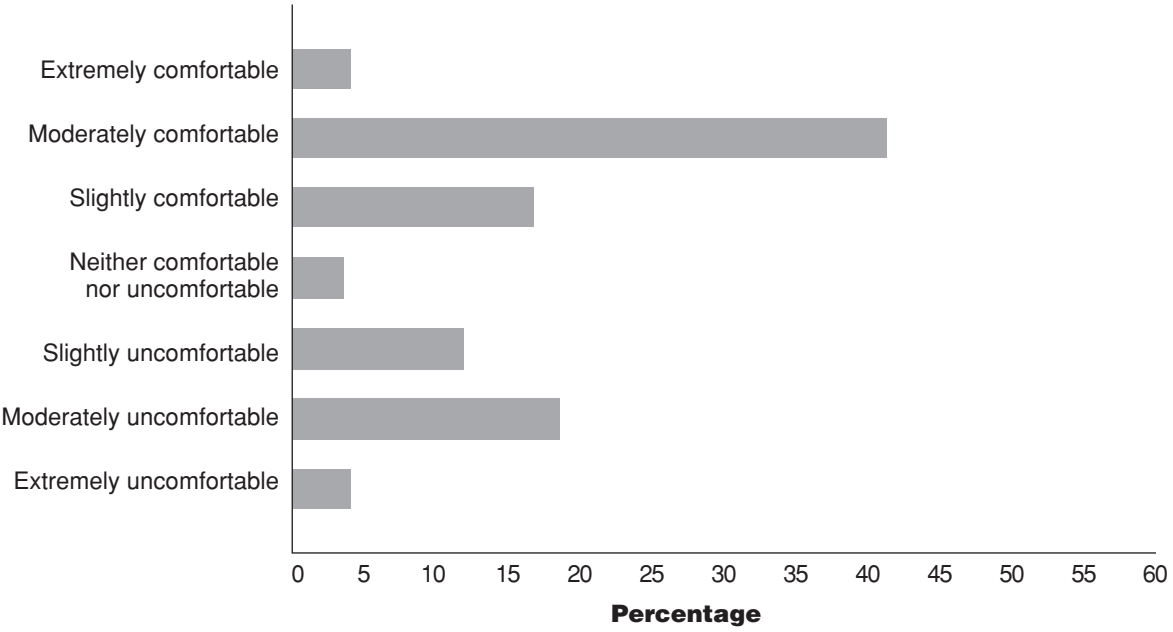

Figure 3. Teacher comfort with current instructional modality.

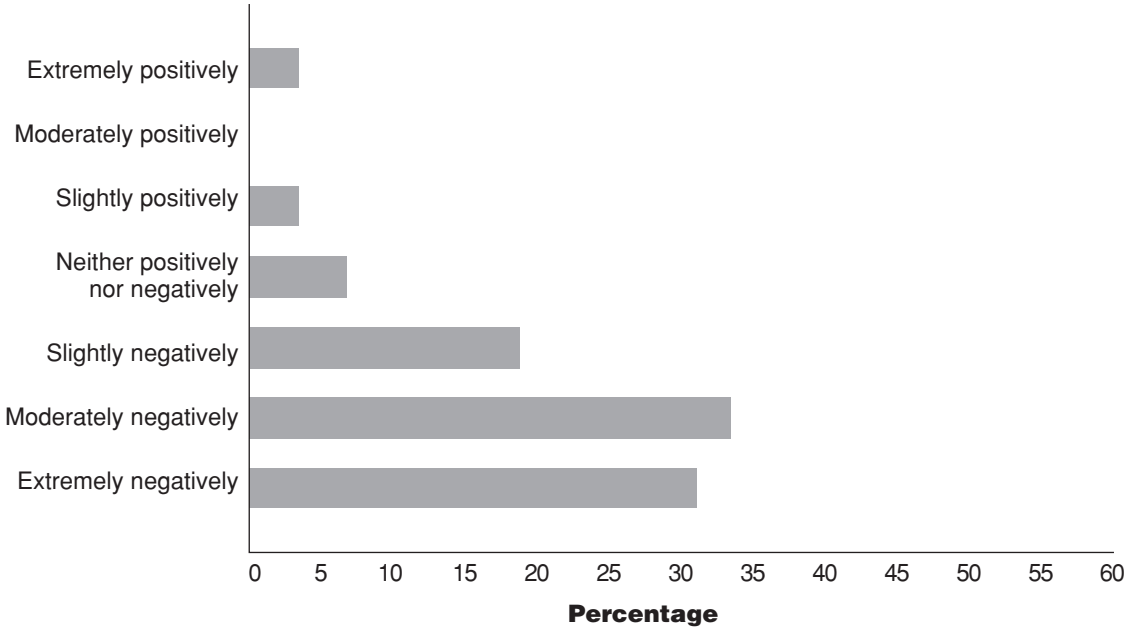

Figure 4. Teacher perceptions of COVID-19 effect on teaching and learning.

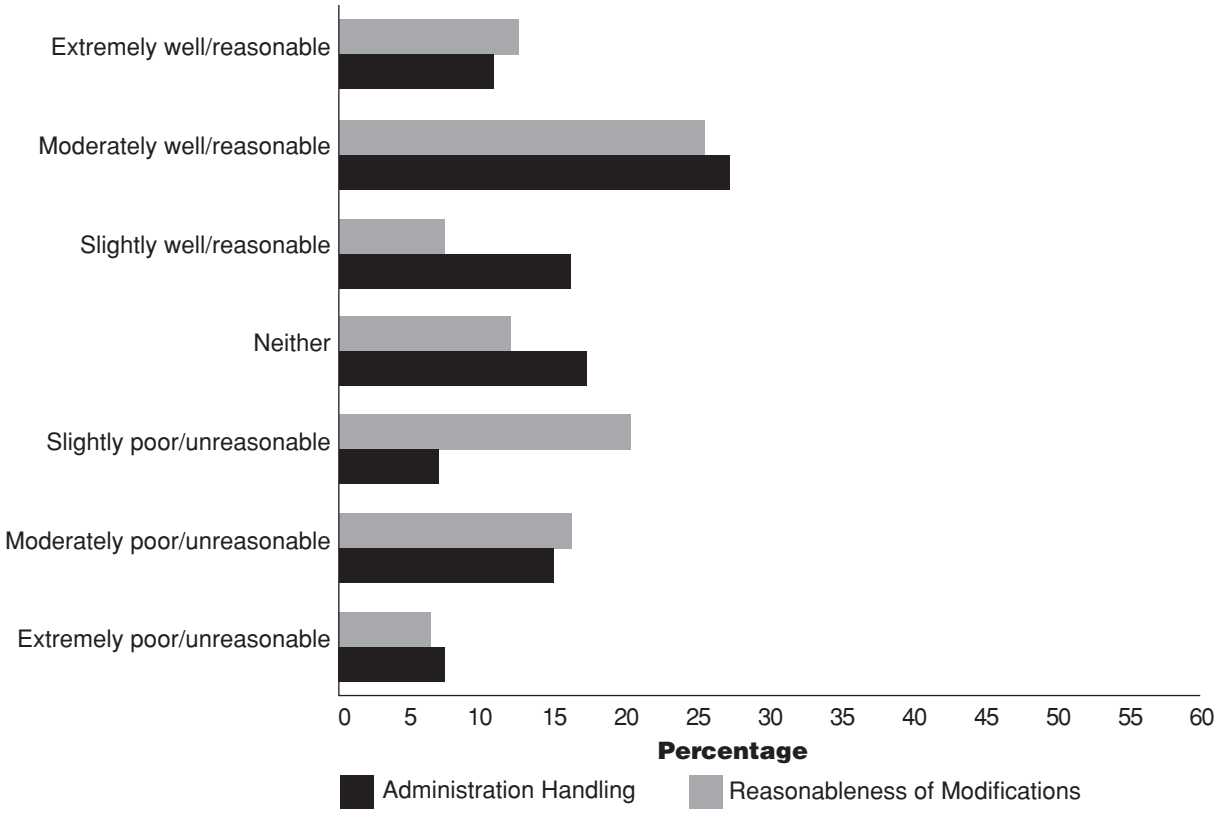

Figure 5. Teacher responses to administration handling and modification requests.

additional hours per week as a direct result of COVID-19. The remaining respondents reported working an average of 7.7 additional hours per week. Unfortunately, the response options ranged from 1 to 10+ and did not fully capture the number of hours worked. In retrospect, the scale should have gone higher, but the sheer percentage of teachers working an additional ten or more hours was not conceived of during the survey development.

Even if the average number of hours spent working among this group is closer to 10 additional hours, this represents a substantial extra workload for TEE teachers. Although there are conflicting reports of the actual hours per week teachers work, with one report claiming approximately 53 average hours per week (Mayer & Phillips, 2012) and another claiming 42 hours per week (West, 2014), if 10 hours are added to the low-end estimate of 42 hours per week, TEE teachers are working at least, 23.8% more hours at 52 hours per week and conceivably more than 65 hours per week with no additional pay and limited, if any, additional supports.

What is troubling about the additional workload is the potential for teacher burnout or attrition. When asked the likelihood of returning to the classroom next year if the conditions were similar to the current environment, 17.0% of respondents indicated they were unlikely to return. Another 10.6% responded they were unsure. Most, 40.4%, indicated that they were extremely likely to return, but with 27.6% of current teachers who responded to this survey unsure or unlikely to return to the classroom, there is cause for concern. Further, of the teachers who responded that they were working an additional ten or more hours per week, 42% were unsure or unlikely to return to teaching next year, with 26% unlikely and 16% unsure.

MODIFICATIONS

Teachers were asked to describe the modifications they have had to make due to COVID-19 and the challenges these changes presented. Respondents were given the opportunity to answer in written form as the number of potential options was vast. These responses were coded and categorized to represent the most common themes. Time, student engagement, curriculum modifications, software, and technology issues, digitizing their instruction and curriculum, and the loss of group work were common threads throughout their answers.

"Time. Resources. There is only one of me." This response to the challenges of TEE teaching under

COVID-19 succinctly sums up the comments of the teachers who participated in this study. Teachers are spending "excessive amounts" of extra time grading, modifying curricula, finding software alternatives, and simply "finding the time to get everything that needs to get done completed in a school day," causing many of the responding teachers to report their challenges as simply "exhaustion, fatigue, and added stress." Several teachers reported having to spend additional time covering for sick colleagues, with one teacher having to "teach two courses at the exact same time."

Having to create lessons for both online and face-to-face students, recreating lessons to be taught virtually that were never designed for online teaching modalities, and having to adapt lessons that require different software and materials "because some students have tablets, some Chromebooks, and some laptops. The software does not work on some devices" is adding work, time, and stress to an already overtaxed workforce. Teachers have to "entirely rethink and redesign how the curriculum is delivered" and further "revise the curriculum to meet the needs of students with no materials and poor internet." Teachers frequently reported having to modify their entire curriculum several times to keep up with changing policies, modalities, and students going in and out of quarantine. One teacher stated that "modifying everything is a challenge," while another simply wrote, "I hate it." Another teacher "was given three days' notice to put together an entire curriculum for the year that meets the COVID changes."

For a discipline that prides itself on hands-on and collaborative work, the TEE teachers repeatedly pointed to the lack of group work and hands-on activities as the most significant challenge they face. "The students are not getting the education they deserve," noted one teacher while another "had to give up most group work as we are 100% [distance learning]." Even teachers who are "fully face-to-face" have to teach virtual students because they are in and out of quarantine. Some teachers "have dropped all hands-on projects because [they] don't have enough materials for students" to work with individually and they cannot share and "many of the [redacted curriculum] modifications for hands-on activities are literally 'wait until you are in person again.' So [they] have to redesign at least half of the curriculum content."

Many teachers reported difficulty engaging students either as a result of remote learning, lack of engaging lessons, and technical difficulties, but largely they feel that it is "not as much fun for students" as they are not getting "the authentic experiences of [TEE]." The report that lessons are "watered down" and "not as rigorous" as a direct result of COVID-19 related changes.

SAFETY

Safety is a core component of TEE, generally. In addition to standard practice, COVID-19 has brought with it the need for sanitary practices that affect not only instruction but also the methods by which TEE curricula is taught. As stated previously, teachers reported the lack of ability to do group work, or hands-on activities at all, to be a challenge while teaching during a pandemic. Teachers were asked what safety measures they have taken directly related to COVID-19. Nearly all responded that they limited or eliminated group work, social distancing, sanitized equipment, and enforced mask-wearing. Many reiterated the lack of hands-on activities and lack of collaborative work noted above as necessary safety precautions. Responses to this question were remarkably similar, indicating that the standardized guidelines recommended by the government/CDC are being followed by the teachers and schools covered by participants in this study.

The need for safety in order to reduce viral transmission has had an impact on TEE instruction. The lack of collaborative group work, changes to assignments, inability to use materials that cannot be properly sanitized or are not available in quantities which allow all students to have their own (e.g., robotics control units), and the fact that some students who are virtual have negatively impacted TEE instruction. Most concerning is the loss of hands-on learning for many of the teachers responding to this study. Concern for student health and the need to limit contact with each other or common materials and equipment has led to the removal of an instructional model long held to be central to TEE. Additionally, teachers reported that when they do incorporate hands-on activities, time is lost due to the added need for sanitation.

What is not clear from the responses is whether collaborative and hands-on work is not possible due to COVID-19 or if the additional safety requirements make these activities more difficult and time-consuming and, therefore, less viable of an option. It is clear that a few teachers are able to continue some or all of the activities that were possible before the pandemic, even if limited in scope. Still, it is unclear if these fully comply with CDC-recommended

protocols, are limited (or not limited) by school or district mandates, are possible as a result of having substantial amounts of equipment, or have found creative methods by which to continue to use collaboration and hands-on activities. Of course, there is the possibility that these teachers are ignoring guidelines or are expending more effort to find ways to continue to incorporate these strategies. What is known is that teachers who are managing to do so are the exception, not the rule.

MORALE

The final question of the survey allowed teachers to add any additional information that they wanted to add. While many of the open responses to specific questions revealed a frustrated and over-worked population of educators, the responses to this question were outright dark and present a clear and present danger to TEE education, if not education in general, unless solutions can be derived quickly. One teacher responded to the request for participation in this survey on Facebook by thanking the researcher for simply asking them how they were coping with COVID-19 in the classroom. Calling completing the survey "therapeutic," the teacher stated that they were able to say things anonymously in the survey that they felt unable to say out loud at school. Principals, instructional coaches, superintendents, and any other person in a position that has the ability to influence morale should heed the gross negativity and desperation provided in these teachers' responses. Only three, of more than thirty responses, could be characterized as positive, and these pointed out that the pandemic allowed them, and their students, to focus on social and emotional health rather than on TEE content, forced the students to "think outside the box," and offered smaller class sizes with fewer discipline problems since half the students were not in school. The remainder of the responses provide a troubling glimpse into the psyche of teachers who are teaching in an environment that could not have been conceptualized even one year ago.

"We are overwhelmed, we feel unsafe, and we have no recourse beyond leaving our jobs," wrote one teacher who went on to say, "I have never felt as helpless as I do right now." One teacher lamented that they were unable to see family members because their job requires them to be "exposed to 60-80 different students each day," and they do not feel it is appropriate to expose elderly family members to potential infection. One teacher responded with, "I hate my job. It's not fun," only to be followed by another who said, "I'm retiring. This is it. This will change education and not for the better." Another teacher stated that "There has to be a better way," with another commenting, "This is not sustainable," and, in what seems like an appropriate summary of the responses, another teacher simply wrote, "The cure is worse than the disease."

The demands of teaching under these conditions coupled with the demands placed on teachers by administrators still trying to run schools and districts with standards similar to those of pre-COVID education are leaving classroom teachers frustrated and saying, "There's no way to keep up with the demands." Even in cases where teachers that recognized that their administrative teams acknowledged the stress they were under, they also reported that "Admin keeps praising us yet keeps piling on bullshit work because we are such amazing workers." The juxtaposition of teachers feeling like principals are "doing the absolute best they can," but then state that the requests are "physically impossible to do" demonstrate that the teachers who responded to this question feel trapped and believe instruction is "not going well at all."

One teacher said, "We are professionals, we adapt and overcome." Many of the teachers who responded to this survey are clearly using it to vent their frustrations about a situation beyond their control. Despite their negativity, they are continuing to forge ahead; but at what cost? One teacher, looking ahead to next year, feared that "This pandemic is going to kill our numbers for next year, I highly doubt students will be electing to take our courses after this year because they were all hoping to be hands-on and building stuff." Other teachers question the value of continuing to teach by outright saying they are going to quit or stating that the "pay for the amount of work is definitely not enough." Still, others are concerned that "so many students are being lost" because they "do not have access."

When teachers were given an opportunity to openly provide their feelings and opinions, the results paint a picture of a tired faculty who are concerned about their students, their future as educators, and their health. They also show a group of professionals dedicated to their profession, with some continuing to teach even after their own COVID-19 diagnoses forced them to do so in quarantine themselves. These responses also demonstrate that education has a morale crisis that needs to be addressed.

DISCUSSION

It is vital to study the effects of COVID-19 on society and education and to report how institutions handled the pandemic if the phenomenon is to be truly understood. To do this, there must be a record of how educators felt in the midst of COVID-19 and not just how they feel after the crisis has abated. Further, it is unclear when this crisis will end, what adjustments can be made immediately, or what the long-term impact of this "pandemic pedagogy" will be. As in other crises, real-time information is needed to direct practice as the crisis unfolds (Institute of Medicine; IOM, 2015). This study, although limited in scope and scale, seeks to provide information on the thoughts, feelings, and actions of TEE teachers amid the COVID-19 pandemic.

In doing so, it is important to acknowledge the limitations inherent in this type of study. There are tens of thousands of TEE educators at the K-12 level across the United States, of which this study captured a small percentage. Additionally, this survey was distributed through social media groups, and it is not possible to know the number of active members of these groups, or how many members overlap into several groups, so a response rate is impossible to calculate. It must also be acknowledged that this is essentially a straw poll and may or may not be representative of the larger population of technology and engineering educators.

These limitations aside, the responses to this study show a field in crisis. Whether a large number of TEE educators leave the classroom due to COVID-19 or the accommodations and modifications necessitated by it, there has been a tangible effect on TEE instruction and education as a whole that will not be fully understood for decades. The "COVID Gap," as it has been described colloquially, is not fully understood or quantified, for a variety of reasons, but undoubtedly exists. Instruction and educational time have been lost, whether solely as a result of the large-scale shutdown of education in the spring of 2020 or in combination with the challenges of teaching during the 2020-2021 academic year, which will undoubtedly have some negative effect. The first cohort of K-12 students that will graduate from high school without having been directly impacted, in formal education, from COVID-19 will likely be in the spring of 2035. This makes understanding, fully, the effects of COVID-19 on education a critical area of investigation, including the real-time impact on teaching and teachers.

CONCLUSION

Overall, COVID-19 has had a largely negative impact on technology and engineering education at the K-12 level. TEE teachers who responded to this survey reported working more hours to accommodate changes necessitated by COVID-19 but felt that teaching and learning were still negatively impacted by the disruptive nature of those modifications. Teachers reported that hands-on learning, collaborative and group work, and their ability to use many of the tools, equipment, and software fundamental to their curricula were hampered because of social distancing, safety, sanitation concerns, and virtual and hybrid learning environments. The varied instructional modalities have limited, or rendered moot, many of the activities on which these teachers have relied and forced teachers to improvise lessons or instructional models or scrapped lessons all together because students could not access materials or engage with the content.

This research presents a potential crisis in TEE with some teachers ready to leave the classroom and many students missing valuable instruction. It is important to understand the impact of COVID-19 on educational outcomes in order to begin the process of addressing the losses incurred as a result of the modifications this global pandemic has required. It is also important to understand what our teachers are currently experiencing in order to mitigate the impacts now rather than address them after the fact. Lest we forget, at the time of this paper, we are still in the midst of this pandemic pedagogical crisis and will likely continue to experience the educational effects of COVID-19 far into the future. Therefore, we must understand the crisis as it unfolds to combat the deleterious effects and meet the needs of our teachers and students.

Dr. Daniel P. Kelly *is an Assistant Professor of STEM Education in the Department of Curriculum and Instruction in the College of Education at Texas Tech University, Lubbock. He is a member of the Alpha Pi chapter of Epsilon Pi Tau.*

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