Effect of COVID on a High School Engineering Curriculum (Work in Progress)

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Abstract:

The COVID-19 pandemic disrupted education on all fronts with no warning. While universities largely adapted by moving lectures from in-person to online, the response from the K-12 community was not as straightforward. Existing issues of equity, access, and inclusion required school districts, schools, and teachers to adopt a variety of untested solutions, including online instruction, canceled classes, and shipping materials/supplies to students at home. The pilot year of a project meant to introduce engineering to K-12 students, e4usa was largely running as anticipated when the COVID disruption derailed the pilot cohort of teachers. This unexpected transition provides a unique opportunity to understand changes that were made and the drivers for those changes, especially when implementing a new and innovative engineering curriculum.

We know that high schools adapted quickly. This work-in-progress discusses initial findings from teacher interviews on their experience during this unforeseen and unique transition. Teacher interviews were analyzed to examine the impact of the COVID-19 disruption from the perspective of a teacher new to an engineering curriculum. Specifically, we will begin to examine the following research question: *How did the pilot year e4usa teachers adapt and deliver the curriculum during the COVID-19 disruption?* We explored teacher delivery of the e4usa curriculum through a variety of levels to capture the drivers that prompted decisions, identify pedagogical adjustments, and identify drivers behind the chosen changes.

Background:

As COVID emerged unexpectedly during the 2020 Spring semester, educational institutions all over the world had to pivot and adapt, utilizing alternative modalities to deliver curriculum to their students. When the disruption occurred, there was little to no consistency in the directives of local K-12 administrations as they began to react and adapt to the new education climate. Variations included trying to continue with the curriculum via video conferencing software and work at home projects, highly modified curriculum with at-home projects, and explicit directives to stop teaching for this academic year. Further complications arose when some students and teachers were faced with the challenge of insufficient home technology and/or unreliable internet access, creating equity, access, and inclusion issues [1-3]. An anonymous social media post had interesting insight:

> "We gave educators almost no notice. We asked them to completely redesign what school looks like, and in about 24 hours, local teachers and administrations fixed it. No state or national agency did this, the local educators fixed it in HOURS. In the midst of a global crisis. In fact, state and national policies actually created roadblocks. Local schools figured out how to work around these. No complaining, no hand wringing, just solutions."

The e4usa pilot year teachers experienced this same disruption while teaching the e4usa curriculum in March, during the second semester of the 2019-2020 AY. The e4usa program emphasizes the "for us all" component, offering all high school students an opportunity to explore and discover what engineering is all about. This authentic project-based curriculum emphasizes the inclusion of diverse groups of students who may not have considered engineering as a viable career path. Although the seven-unit curriculum was intentionally designed to immerse students in four unique threads [4]; discover engineering, engineering in society, engineering professional skills and engineering design, most pilot year teachers were only able to complete the curriculum through Unit 4: Engineering is Responsive or Unit 5: Engineering is Intentional as a result of the pandemic. Although the disruption did lead to incomplete coverage of the curriculum, the inaugural teachers found unique ways to adapt and provide adequate project and design experiences for their students.

This study will yield value for the educational community as research during and after the initial effects of the pandemic, looking back to find out what worked, what didn't work, and what can be learned to improve current and future practice [5]. This study will also allow the e4usa team to develop a framework to advise and inform both internal e4usa stakeholders and external education communities. Dissemination of these findings has the potential to inform projects incorporating teacher professional development, those funding and researching engineering in K-12 settings, local school administrations, and other universities interested in working with K-12 schools. This unique opportunity may be the only mechanism to truly understand how to plan for, rather than react to, future catastrophic interruptions.

Methodology:

This phenomenological approach aimed to provide detailed examinations of the teachers' personal lived experiences and sought to gain insight into how they made sense of the phenomenon [6], offering the reward of "seeing-meaning" into the heart of things [7]). This study utilized Interpretative Phenomenological Analysis (IPA) in an attempt to make sense of the participants trying to make sense of what has happened to them [8]. Participants in this study may have experienced extraordinary emotional stressors due to their experience of the pivot. In addition, announcements from school districts hinting at the need for another shift to remote teaching for the 2020-2021 academic year surfaced during the interview phase of this study. Each of the nine pilot-year high school teachers who taught the e4usa curriculum during the 19/20 AY were invited for the study. This purposive sampling approach was used because this non-randomized group yielded common experiences as each were a pilot year teacher and taught the e4usa curriculum during the Spring 2020 COVID-19 disruption. This chosen population was interviewed by facilitators of the e4usa project team. Due to existing social distancing policies, interviews were conducted virtually utilizing zoom on a password protected network, and recorded using Otter.ai to transcribe the data and uploaded to Dedoose for coding. Upon completion of data collection for each participant, interview transcripts were analyzed using Dedoose. The first round of inductive coding was completed and this first pass looked for emerging themes.

Initial interview questions focused on challenges faced by teachers as the COVID-19 pandemic hit, and how they adapted to changes in delivery methods. Questions also focused on the drivers

behind these changes, asking how the district responded. Further questions focused specifically on the e4usa curriculum, asking how far teachers had progressed through the curriculum at the time of the disruption and whether they would have signed on to teach e4usa had they known in advance that the program would be delivered online. Follow-up questions were asked in almost every instance.

Teacher focus groups were also facilitated during the summer 2020 professional development modules capturing the perspectives of the incoming e4usa teachers for the 2020-2021 academic year, illuminating some of the same challenges experienced by the pilot year cohort. Finally, teacher responses to surveys administered through Canvas (LMS) were reviewed and included when COVID-19 was mentioned.

The e4usa program is taught in many different school districts across the country, requiring different strategies based on state and school district mandates.

Participants:

The entire cohort of nine pilot year teachers was interviewed and participated in focus groups. Each also was active on Canvas to a varying degree. Teachers' backgrounds ranged in level of teaching experience, ranging from approximately five to twenty-five years of teaching experience. As first year pilot teachers, the e4usa curriculum was new to each in the cohort of teachers. The teachers' district varied from Large City Public (3), Large Suburban Public (4), Remote Rural Public (1) and Large Suburban Charter (1). Teacher experience with engineering varied as well, from a teacher who had practiced engineering to a music teacher. Pseudonyms are used throughout this paper.

Preliminary Results:

Data collection continues, particularly through Canvas (LMS), in teacher reflection and future focus groups. We expect more data to emerge as we progress through the year.

From our initial findings, the main themes that emerged from teacher interviews were adaptations (communication with students), student motivation (grades and student engagement), digital equity (laptops and internet access), successes (alternate projects) and teacher future plans.

Grading proved challenging for many of the teachers in terms of student motivation. Jack, an e4usa teacher, expressed "In Pennsylvania here, our governor, sort of in part of the decree said that no student could fail, on account of the COVID outage, which got to kids very quickly, and that had a pretty big impact". Not only were teachers challenged with the online modality, they also had to discover additional motivational strategies to keep their students engaged.

Communication with students was a challenge, even though teachers implemented multiple communication strategies such as zoom office hours to meet with the students as a way to connect one-on-one. Others relied on email and Google classroom for communication. Allen expressed, "So we had, we had to do emails, so we had to stay pretty much constant, check your

email at least an hour every hour, and respond to student emails to respond to parents. My particular stance was to do that. I also checked my Google Classroom posted assignments there. I did do zoom meetings with my physics classes. My engineering classes chose not to do so". Student engagement was challenging as described by Joe, "But long story short, I would say that once we adapted Canvas and started teaching online, we found that our students, even though we gave them the technology, many of them were disengaged and then were either watching siblings or just not coming to school at all. And then if they did do it, they just did it on their phones. So I know that the lesson we learned is how – was the lack of engagement and how we're gonna try to overcome that because technology was provided, hotspots were there, it's just they weren't engaged in learning." Even though teachers implemented multiple communication strategies, communication was still a concern. The full impact of digital equity was unanticipated; many students did not have access to the internet or the necessary hardware needed to access their course materials remotely. This situation sent many districts into call to action mode, teaming with local internet providers and providing laptops to students. Unfortunately, laptop availability was not always one to one as expressed by Bill, "Each school had to disseminate computers and the number of computers we had to disseminate was much less than the need of our students". As one alternative, schools provided paper packets to students who could not acquire a laptop or gain reliable access to the internet. John expressed, "But we were to use google classroom, and then anybody that didn't have the internet access, because a lot of our students didn't have, they would do paper packets".

Although certainly blindsided by the abrupt modality shift, teachers and students both stepped up to the challenge. The e4usa curriculum is situated in project teams, which calls for the integration of atypical projects. Along with online curriculum delivery, teachers were able to adapt and find appropriate projects for their students. For example, an e4usa teacher embraced the opportunity afforded by a pandemic and provided an opportunity for her students to work on a PPE project, fitting an eye care exam room's clinic with protective shields. Bob expressed "We were doing our own projects and trying to go through that we had met with a brick maker and made their own bridge, kind of a community project and learned how 3d printing would go into designing".

Although the e4usa curriculum was not initially designed as an online course, each of the nine pilot year teachers confirmed that they would have still taught the course if they knew it would be online, and they would be interested in teaching the curriculum again after the COVID disruption, whether the curriculum was in-person, hybrid, or completely online. This is promising news for the e4usa team as we move forward with continuous improvement efforts in the areas of curriculum and professional development as we prepare for the 2021-2022 academic year.

Discussion and Implications:

Most educational institutions formulated some type of alternative course delivery strategy as they approached the 2020-2021 academic year. The results of this study begin to describe a deeper understanding of the teacher's challenges, successes and failures when they shifted to an alternative course delivery method, and to illuminate the importance of proactive emergency instructional design models, and collaboration amongst educators. As the e4usa teachers had to adjust their course delivery, the e4usa team had to adjust and the summer 2020 teacher

professional development module to one that was facilitated online. Our preliminary results showed that teachers, for the most part, successfully transitioned despite a lack of a coherent or planned plan. Issues of equity remain: teachers in this program tackled the issue to the best of their ability, but the pandemic exacerbated preexisting, much larger issues.

Our initial cohort was intentionally part of a Community of Practice, and we found that this arrangement allowed teachers to help and support each other, even with vastly different challenges at the local level. The entire cohort of nine teachers stated unequivocally that they would have taught this new curriculum, even considering the disruption. This implies a value of the community support and a value of the class as viewed through the lens of the teacher.

The e4usa teachers were able to inform the development of our online professional development program as a result of their own remote teaching experiences.

Further work remains to incorporate other teacher feedback into a more complete analysis. Teachers also gave regular reflections through the course management site, and participated in focus groups a few times throughout the year. This initial investigation of individual teacher interviews, when supplemented with this additional data, should allow us to investigate teacher motivation and perception of success more fully.

Acknowledgements:

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