It's Virtually Possible: Rethinking Preservice Teachers' Field Experiences in the Age of COVID-19 and Beyond

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Abstract: Mid-semester Spring 2020, most universities and K-12 schools in the US transitioned into fully online teaching and learning as a result of the COVID-19 pandemic. This required K-12 teachers with no prior training or experience to teach online. With online learning likely to have a lasting presence in K-12 education, preservice teachers (PSTs) must be prepared to deliver virtual instruction. This chapter offers lessons learned by teacher educators who guided PSTs in the modification of hands-on engineering lessons for virtual implementation during the Spring 2020 semester as part of an NSF-funded project. PSTs delivered engineering lessons both synchronously and asynchronously to elementary school students and reported positive learning opportunities, gaining confidence and competence from their experiences. The authors assert that if online teaching experiences can be crafted carefully and intentionally for PSTs, rather than adapted on the spot in response to a sudden shift to virtual learning, there may be even greater potential for learning and confidence building. Successful strategies for both asynchronous and synchronous instructional field experiences are shared and implications for both teacher educator practice and research are made.

Lesson Learned: Preservice teachers benefit significantly from virtual field experiences with K-12 students; teacher educators can, and should, provide these opportunities to prepare teachers for a post-COVID-19 world.

AN INTRODUCTION TO ONLINE ENGINEERING EDUCATION FIELD EXPERIENCES FOR PRESERVICE TEACHERS

After K-12 schools in the US transitioned fully online due to COVID-19, studies that explore the impact of the pandemic on teaching emerged (Nuere & de Miguel, 2020; Romero-Rodriguez et al., 2020). However, most of this early research addressed teaching and learning in higher education rather than K-12. Researchers have just begun to examine the rapid shift from in-person to online teaching and learning, capturing teacher educators' field stories and innovative approaches to using technologies to provide meaningful learning for PSTs during a pandemic (Ferdig et al., 2020; Hodges et al., 2020). Many teacher preparation programs have only begun to partner with K-12 virtual schools to prepare PSTs to teach online in the K-12 environment (Archambault et al., 2016). Hence, there is limited literature that examines field experiences where PSTs directly interact with and prepare to teach K-12 students in online environments. Nevertheless, the experience of a team of educators in Spring 2020 strongly suggests that PSTs can benefit significantly from K-12 virtual field experiences.

In Spring 2020, Ed+gineering, an NSF-funded project, partnered undergraduate engineering students (UESs) and preservice teachers (PSTs) together to learn from and with each other as they planned and delivered engineering lessons to elementary students. The extensive project involved three collaborations between the two groups of college students (Figure 1). While each collaboration was planned to occur face-to-face and result in in-person lessons with children, a modified plan was enacted mid-semester to shift the lessons for online delivery. This chapter highlights lessons learned by Ed+gineering's teacher educators following the modification of their engineering lesson project for the virtual learning context. It reveals how virtual teaching opportunities with K-12 students provided critical learning experiences for PSTs. Holistically, these collaborations have broad implications to the larger teacher educator community, demonstrating how PSTs can be prepared to teach online through asynchronous and synchronous virtual field experiences.

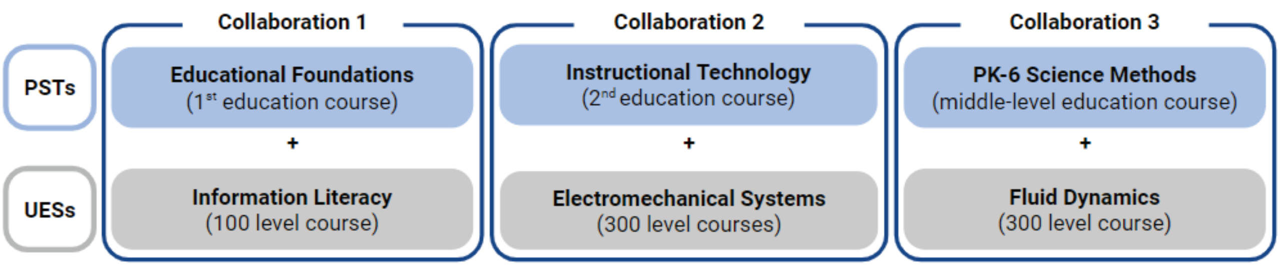

Figure 1. Three Collaborations of the Ed+gineering Project.

WHAT WE KNOW

PSTs' Field Experiences in Online Settings

According to Tobin (1993), teachers learn best when they have direct experience with their students. Such direct experience is valuable because it provides PSTs with the most compelling source of teaching efficacy, student performance (Liaw, 2009). Considering that practical experience with students has an impact on PSTs' teaching efficacy, which in turn affects students' achievement (Riggs & Enochs, 1990), it is critical for PSTs to experience teaching K-12 students in authentic contexts before entering their own classrooms (Hunter & Botchwey, 2017).

Field experience is an essential component of teacher preparation where PSTs contextualize knowledge and theories (Darling-Hammond, 2014). Researchers have consistently expressed the need to prepare PSTs to teach online to prepare teachers for the 21st century (Ferdig & Kennedy, 2014; Irvine et al., 2003); however, little has changed in the past ten years to provide such preparation (Kennedy & Ferdig, 2018). A national survey conducted in 2010 by Kennedy and Archambault (2012) found that only seven programs nationally, or 1.3% of US teacher education programs, offered virtual field experiences to PSTs. After four years, the authors (2016) replicated the study and found only a small increase to 15 programs, representing only 4.1% of teacher education programs across the US. Thus, there is a significant gap between the growing need for online education and teachers' preparation (Larson & Archambault, 2019; NFES, 2015). Consequently, at the time of school closures in Spring 2020, only a small portion of teachers and teacher educators had been trained to teach online (Larson & Archambault, 2019). It is not surprising then that the shift to emergency remote instruction took many educators in both K-12 and higher education by surprise; hence, they were unprepared to teach in online settings when COVID-19 forced schools to close in 2020.

In order to provide meaningful online field experiences for PSTs, teacher educators need to be prepared. However, teacher educators were found to have limited knowledge about K-12 online learning, with some believing that simply having PSTs take an online course would be adequate preparation for teaching one (Kennedy & Archambault, 2012). Guiding PSTs to teach online goes beyond introducing technology skills and requires a different skill set (e.g., content delivery, classroom management) from traditional face-to-face teaching (Kennedy & Archambault, 2012; Larson & Archambault, 2019). Virtual field experiences situate PSTs to develop the skills and knowledge needed to effectively teach in an online environment. For example, PSTs who were exposed to virtual school environments gained a better understanding of the responsibility and skills of a virtual teacher, overcame concerns and misconceptions about K-12 online learning (e.g., thinking it would involve less teacher-to-student and student-to-student interaction than face-to-face settings) (Compton et al., 2009), and developed a positive perception toward K-12 online teaching (Luo et al., 2017).

Nationwide, as PSTs were unable to complete their face-to-face field experiences due to school closures in Spring 2020, teacher educators had to explore unique ways to make field experiences meaningful for PSTs. For example, Kier and Clark (2020) implemented a Virtual Tutoring Program, where PSTs would meet weekly, one-on-one, with 3-5 elementary students by phone or in virtual meetings in order to both address issues of equity in online teaching and provide tutoring services to identify problems and potential solutions. Koch and Vu (2020) arranged Zoom-based field experiences for their special education PSTs, in which they met with K-12 students with disabilities, as well as the students' parents and teachers, in order to provide a realistic replication of a face-to-face meeting where the stakeholders discussed the child's home and school experiences with regard to their identified disability and accommodations. Moreover, teacher educators incorporated innovative ways to provide virtual substitutes for the face-to-face field experiences that PSTs missed as a result of school closures, such as technology-based simulated professional development environments (Sasaki et al., 2020), virtual reality simulations (Monroe et al., 2020), and video-based case studies (Kerkhoff, 2020). These alternative field experiences for PSTs were found to be viable options for substituting traditional face-to-face field experiences from both the instructors' and students' perspectives.

Asynchronous and Synchronous Learning for Teachers and Students

There is ongoing debate on the benefits and challenges associated with the two main types of online learning: asynchronous and synchronous. While asynchronous learning allows time for learners to process information (Robert & Dennis, 2005), students can feel isolated and have fewer opportunities to process information with others (Haythornthwaite & Kazmer, 2002). Synchronous sessions, especially those with video interaction, often provide space for richer verbal communication, allowing students to clarify problems quickly and easily, feel less isolated, and perceive greater social presence (Lowenthal et al., 2017). Burgoon et al. (2010) observed that synchronous sessions resulted in higher levels of engagement than asynchronous, promoting a stronger sense of connection, presence, and social awareness in the conversation.

It is not surprising then, that despite the convenience of asynchronous learning, many students and teachers choose synchronous learning over asynchronous as it is perceived to be more social given the opportunity to simultaneously ask and answer questions (Hrastinski, 2008). However, synchronous learning is not without concern as it can easily turn into long one-sided lectures, which makes it difficult to participate and leaves people fatigued (Schulman, 2020). While both modalities have limitations, research suggests online learning has some benefits over face-to-face environments. For example, researchers (e.g., Borup & Stevens, 2016; Graham, 2006) found that online communication allowed more personalized communication than face-to-face learning environments because teachers can work with individuals more easily. Given the pros and cons of both models, it has been suggested that teacher educators prepare PSTs to utilize both, depending on the complexity of the teaching activity and the need for social interaction.

Teachers' Need for Autonomy

Littlewood (1996) defined autonomy as one's ability and willingness to make choices independently. When autonomy is viewed from a teacher's perspective, the ability to control content and environment is a key (Pearson & Hall, 1993). In an online setting, teachers were satisfied when they had flexibility in when and how they taught and had time to interact individually with students (Borup & Stevens, 2016). Moreover, Ketelaar and colleagues (2014) reported that teachers need to sense ownership in order to implement educational innovation. Thus, in order for teachers to implement new pedagogies or educational technologies, they need to first build a sense of ownership. Few studies have investigated factors that foster teacher autonomy. Factors that hamper teacher autonomy are more commonly reported. For example, Xu (2015) identified overdependence on peer support and oppressive circumstances at institutions as obstructing factors. More research is needed to understand how to support teacher autonomy in both pre-service and in-service contexts.

PST Participation in Virtual Field Experiences in Spring 2020

Following the shift to online instruction in Spring 2020, the teams of education and engineering students participating in the three Ed+gineering collaborations were asked to revise their engineering lessons for elementary students to a virtual version, rather than face-to-face delivery. The lesson redesign for Collaboration 1 (C1) and Collaboration 3 (C3) was similar—each team created an interactive multimedia Google Slides presentation (see sample presentations in "Implementations" at https://www.oduedgineering.com/) to interact asynchronously with partnering elementary students. In Collaboration 2 (C2), teams redesigned lessons planned for elementary students in an after-school club for synchronous delivery via Zoom (Figure 2). This chapter will leverage the experiences of the PSTs as they redesigned their engineering lessons for virtual delivery to illuminate the potential advantages and challenges of virtual field experiences.

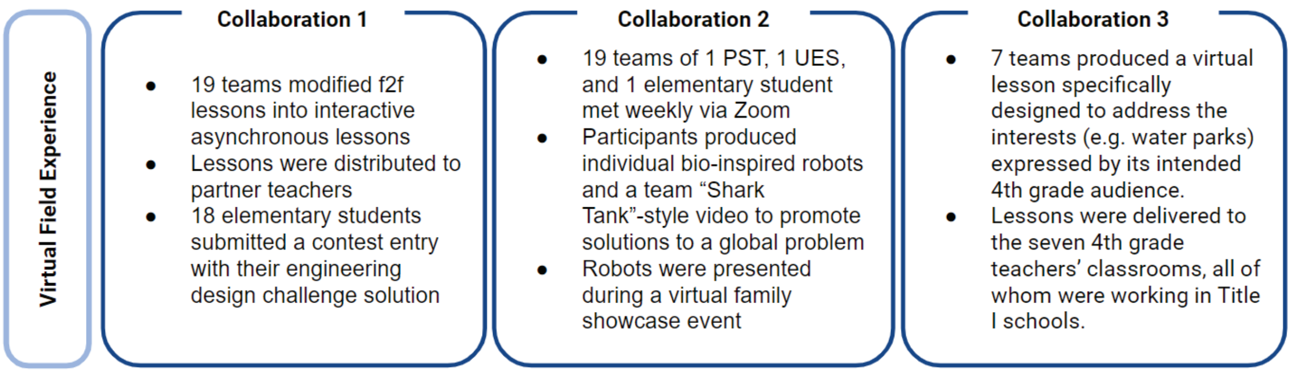

Figure 2. Virtual Field Experience for PSTs.

The following sections draw from PSTs' written reflections and focus groups to provide evidence of the struggles and benefits PSTs reported from preparing to teaching virtual lessons. They highlight lessons learned by the teacher educators as they redesigned the field experiences for virtual implementation. The experience of PSTs who participated in an asynchronous instructional model are described first, followed by a description of the experiences of PSTs participating in a synchronous field experience.

PST Field Experience through an Asynchronous Instructional Model

PSTs Shift their Lesson Design from Face-to-Face to Asynchronous Online. Prior to school closures, teams of 4-6 UESs and PSTs were preparing to deliver hands-on engineering lessons during *Engineering Day*, a field trip for elementary students to visit the university. Mid-semester, teams were tasked with converting their lesson to an asynchronous online format.

What we learned from this shift is that even with additional stressors imposed by COVID-19 and the university's transition to online learning, PSTs noted learning from the preparation of asynchronous instructional material. A C3 PST acknowledged that even though she did not get to teach the lesson face-to-face, she "learned how to do an interactive presentation, which [she'd] never really done with audio or video." PSTs also learned online pedagogical strategies in resource development:

> We also tried to keep the presentation interactive, even though it was a virtual presentation, by adding videos of us also doing the project and adding audio recordings, where we thought the students would need more explanation. We also tried to keep the videos on the presentation short so we would not lose the students' attention.

These were not the original objectives for PSTs in Spring 2020; however, these are essential skills to help prepare PSTs for teaching virtually. As inservice elementary teachers have been asked to utilize similar skills in the 2020-21 academic year (Korkmaz & Toraman, 2020), these skills will be beneficial for PSTs moving forward, even post COVID-19.

PSTs' Interactions with Elementary Students. PSTs expressed disappointment at not being able to interact and gauge the elementary students' responses in real-time. One C1 PST "lost a lot of [her] motivation to continue since [she] would not be able to actually interact with the students in-person or even see them complete the project," while another C3 PST was "all kind of bummed that we had to have a virtual interaction." The distribution of the Google Slideshows to the elementary students was inconsistent, reflective of inadequate infrastructure for K-12 virtual instruction nationwide (Korkmaz & Toraman, 2020). Furthermore, K-12 teachers and students were often not familiar with the technology tools used in the presentations or lacked access to necessary resources (see "Resources" below). Thus, some students were not availed access to the presentations, and interactive elements (e.g., Padlet, Kahoot) were not always used by the intended elementary audiences. This was exacerbated by mandates from school divisions to only provide students with district-prepared classwork packets. As a result, few teams received evidence of elementary student interaction with their lessons. This created a very one-sided asynchronous experience with minimal opportunity for back and forth interaction between the elementary students who were to complete the lessons and the college students who prepared them.

What we learned was that PSTs considered the lack of interaction with elementary students a missed learning opportunity, especially since they were originally slated to work with students in a face-to-face lesson. They were disappointed that they did not receive feedback on their work from their intended audience. They could not fully ascertain if their lessons were responsive to students' knowledge, interests, or cultures. Considering that students perceive feedback as a powerful source for learning (Ferguson, 2011), lack of feedback from elementary students impaired their ability to learn from this experience. Our project team asserts that the asynchronous lesson design (and, by extension, asynchronous teaching experiences generally) were not inherently flawed, but rather were hampered by the lack of expertise and infrastructure for online learning in K-12 schools that existed in April 2020 when the lessons were delivered. Inservice K-12 teachers have since increased their comfortability interacting with students online, and future distribution of asynchronous lessons would likely be more successful than it was during the emergency remote instruction transition.

Modeling Virtual Instruction. To help ensure a high-quality product, the project team created and distributed a highly interactive, exemplar Google Slideshow that included student-friendly images, personal video and audio clips, and tools to promote elementary student interaction (e.g., Google Forms, comments in Google Slides). The team also created a presentation that explained how to create and embed interactive elements (Figure 3), as well as providing a Google Slides template as a starting block for their asynchronous lessons.

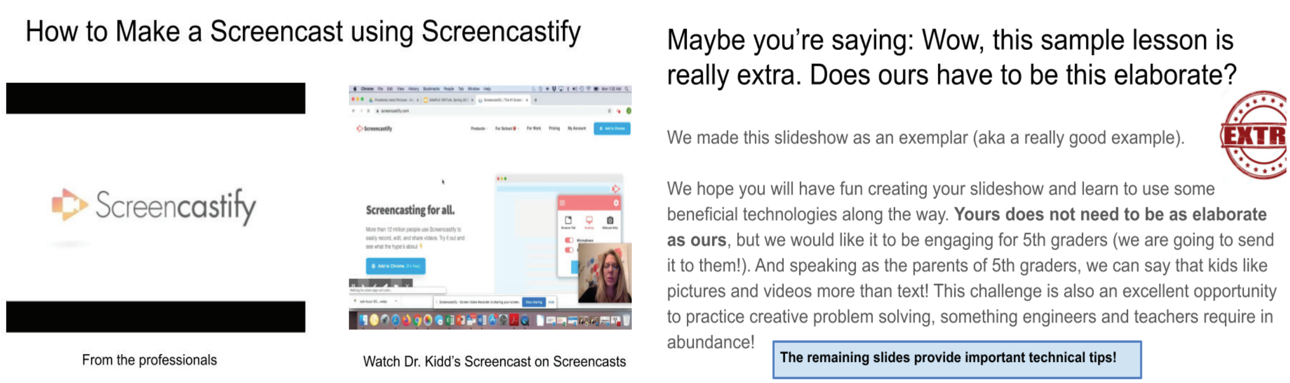

Figure 3. Slides Explaining How to Create and Embed Interactive Content.

What we learned was that PSTs, especially those earlier in their program (C1), valued the digital resource models. One C1 PST explained that "the slideshow templates allowed us to follow step by step on what information we need and what content needed to be put in our slides for our project. These resources allowed us to effectively complete our lesson…” However, some PSTs, especially those further along in their education program (C3), found that the prescriptive nature of the exemplar slideshow minimized their autonomy, their creative ability, and pedagogical flexibility:

> I feel like [the slideshow] should've been more creatively done by us [rather] than a prompt for us to fill out. Because, okay. We did all this work just to fill out this prompt, and it doesn't really match idealistically what I would do….

This aligns with the literature that identified ownership as a critical factor for teacher motivation (Borup & Stevens, 2016; Ketelaar et al., 2014).

Providing Resources for Virtual Learning. Prior to the transition, both university teams and elementary students would have been provided with all physical materials (e.g., styrofoam, tubing) necessary to carry out the engineering lessons. Following the transition, teams had to consider what resources would be available to them in their own homes, as well as to Title I elementary school students, as they (re)designed their engineering lessons.

What we learned was that PSTs benefitted from the real-world opportunity to reflect on resource equity. Most of the participating elementary students are considered ‘high-need' and attend schools that receive Title I funding. Thus, PSTs had to consider whether or not elementary students would have access to the ‘basic' household supplies they planned to ask them to provide. A PST in C1 explained, “we had to be mindful of the supplies they might have at home. We just had to definitely rethink. I don't think it was difficult, we just kind of had to restructure our project.” Hartshorne and Baumgartner (2020) suggested that “educators and teacher educators must inform solutions to resolving equity, accessibility, and other disparities in teaching and learning, as well as provide preservice and in-service teachers with opportunities to understand and address these issues” (p. 603). As PSTs were preparing asynchronous engineering design challenge lessons for elementary students, they were situated in an environment where they had to address equity and accessibility.

Faculty and Peer Support for PSTs. PSTs were supported through this project by their course instructor, their undergraduate engineering student (UES) partners, and the corresponding engineering instructor. Faculty met with teams as needed to provide feedback and direction. PSTs also relied on their teammates. One PST described the transition to learning and teaching online as “surprising, confusing, and challenging” but found their team members and faculty “readily available for any challenges that may arise.” PSTs often relied on their engineering partners to provide expertise on engineering or scientific concepts. A C1 PST elaborated on the importance of his UESs partners:

> The engineering students are very creative and can think on their feet. Without them, it would have been harder to transition from in-person to online. They had ideas ready on how to revise our lesson and activity to work with what the students might already have at home.

What we learned was that many PSTs developed autonomy following the transition. The transition created challenges, especially in team communication, and PSTs had to overcome these by demonstrating initiative and innovation. For example, many teams collaborated less effectively after classes moved online. This often resulted from technical challenges, a reduction in team member input, or teams not communicating as frequently or as richly post-transition. Some PSTs noted that the virtual collaboration environment forced them to act independently and as such, helped them to develop professional skills. For example, a PST in C3 impacted by a reduction in her team members' productivity, reported that her leadership skills improved as she became “more active and express[ed] where the project should go.” She added that this was the first group project in which she “felt comfortable enough to communicate well, and often, about expectations and work quality.” She went on to say that she “can now start to take more leader roles in group projects and work well with others without fearing judgment.” Xu (2015) found that there is a delicate balance, or synergy, necessary when novice teachers work in teams, too much reliance on team members may reduce one's autonomy. Similar to Xu's findings, our team found that a balance of autonomy and support from faculty and UES allowed the PSTs to grow their knowledge and confidence for engineering content and pedagogy, even in a virtual teaching and learning environment.

PST Field Experience through a Synchronous Instructional Model

PSTs Shift their Lesson Delivery from In-person to Zoom. Before the COVID pandemic, C2 teams were planning a robotics project for 5th graders participating in an after-school technology club. The project was the club's culminating design challenge: design, build, and code a bio-inspired robot to address a global challenge. When schools transitioned online, the after-school club did also. Each team of one PST, one UES, and one 5th grader met via Zoom to complete their robotics project.

Shifting to a virtual context meant that the teams needed to re-envision their multi-week robotics lessons for online delivery. PSTs used a variety of instructional technologies to facilitate this. As one PST reported, "Teaching through Zoom required me to find more technology-based activities to encourage participation." Another explained, "I used PowerPoints, videos, and Kahoot to make the learning process more engaging and fun." Many of the adaptations were difficult to plan for ahead of time, however, as they involved addressing emergent student needs (e.g., waning attention, trouble connecting parts) and troubleshooting technical issues (e.g., servo motor not spinning, code not uploading correctly). PSTs had to demonstrate perseverance in order to successfully achieve their lesson objectives. Many issues were only resolved after multiple back and forth screen shares and holding up hardware to the camera (e.g., "put your motor like this….") (Figure 4).

Figure 4. A Team Working on Motor Placement During a C2 Synchronous Lesson.
Note. Undergraduate engineering student (left) and preservice teacher (middle) communicating with 5th grade partner (right) by holding up hardware to the camera.

What we learned was that teaching hands-on robotics online was challenging, but feasible. As one PST put it, "Not sharing the same space was HARD! I could not directly show Rachel how to plug in her wires or save her code to her robot." The myriad of challenges that arose from teaching robotics online forced PSTs to innovate and adapt and they developed confidence from doing so. A PST explained it this way:

> ...getting the chance to teach this, like, crazy, complicated concept over Zoom, kind of makes me like, "Okay, if I can teach this stuff over Zoom, I can teach, like, reading and addition and, like, the more classic elementary concepts."

In addition to gaining technical expertise and confidence, PSTs appreciated the opportunity to teach online. As one PST explained, "I believe teaching through Zoom provided me with the experience in case classes get moved online in the future! Some teachers right now have never had anything like this happen and have struggled trying to teach online." We also learned that many PSTs appreciated and benefitted from the increased autonomy and responsibility they were granted when the club went virtual. As one PST noted:

> Virtual WoW Club gave me more autonomy than in-person WoW Club. I was able to decide what I wanted my student to achieve, the methods of instruction, what topics I wanted them to explore, and how much time I wanted them to work on it.

PSTs seemed to be motivated by additional responsibility, and this, coupled with their interest in assisting their 5th grader, often drove them to invest more time and energy into lesson preparation.

PSTs' Interactions with Elementary Students. C2 PSTs worked one-on-one with a 5th grader during 4 or 5, two-hour Zoom sessions. This extended interaction allowed them to develop a relationship with their student, understand and anticipate their needs, and structure their sessions accordingly. The instructors and teaching assistants would occasionally drop into Zoom sessions for a few minutes, but the PSTs bore the primary responsibility for executing the lesson and meeting its goals. The PSTs were encouraged to learn with, and even from, their 5th grader partners: in some cases, the elementary students had more prior experience with coding or robotics than their partner PSTs.

What we learned was that PSTs learned from their elementary students and enjoyed interacting with them but faced many challenges. Most of the challenges were technical (e.g., unreliable internet, difficulty seeing/hearing students), but many PSTs also discussed difficulty maintaining student engagement, especially given home distractions (e.g., pets, family members). As one PST articulated: "two hours is a really long platform for a fifth-grader on a Zoom call." PSTs noted that the online nature of the robotics project taught their 5th grade partners to be independent. As one PST pointed out, she could not manipulate the hardware or software *for* the students, and her 5th grader "built her robot completely on her own." Another PST noticed that her student "had to be a little more self-motivated, especially when he became frustrated." Yet another recounted having her father, who was listening to her Zoom lesson, laugh when her 5th grader partner said to her “Well, why don’t you just try to do it this way? *Duh*.” Instead of being intimidated or insulted by the student’s remark, the PST was empowered, responding:

> ...it was the truth. He was able to come up with his own ideas in problem-solving. And I was like, ‘Well, we’re both good then if we both can just come up with ideas and figure it out and learn as we go.’

The PST’s developing confidence and positive relationship with her 5th grade partner helped her see the benefit in learning from an elementary student.

Providing Resources for Virtual Learning. Prior to the transition, the plan was for each team to design and build a single robot. When the meetings went online, this was no longer feasible. Without being in the same geographic location, the teams could not work collaboratively on a single artifact unless they were only to guide the 5th grade students in their production. It was determined that all participants would benefit from designing and building their own robots, but to do so based on a communally decided theme. So, each team determined a global challenge that their robot would address and a bio-inspired solution to address it; for example, one team designed seal-inspired robots that could collect trash in the ocean and attract other seals to study migration patterns (Figure 5). Each team member was encouraged, but not required, to build their own robot accordingly. Robotics kits were offered to all participants. This new task of independently building a robot was in addition to the challenge of reconfiguring their lessons for online delivery, adding stress for some PSTs. A few of the PSTs opted not to build their own robot, but the great majority did.

Figure 5. Seal-inspired Robots.

What we learned was that PSTs valued access to the robotics kits and they learned and gained confidence from building their own robots. As one PST explained:

> I think a benefit to moving online was we got our robotics kits mailed to us and so we ended up with a lot more time … to mess with [it] on our own … I was able to code and play with things before the meeting when I had time ... I wouldn’t have had access to [it] if it were just the normal in-class meetings.

PSTs reported that building their own robots helped them teach their elementary partners by preparing them for what to expect and by producing models to share with their students. One PST explained that she was able to “try to build the project before our lesson giving me a better idea what problems we may run into and allowing me to create solutions before they arise.” They added that the kits also enhanced the PSTs’ ability to learn alongside students, “By everyone attempting to create the same thing at the same time we were able to problem solve together, everyone bringing different solutions.” Another PST expressed pride in her accomplishment of building a robot: “I can’t wait to take my experiences and share with my future students and tell them I was an engineer!”

Faculty and Peer Support for PSTs. The shift to a virtual context meant that the C2 teams had to implement their lessons in physical isolation from their instructors and classmates. This generally resulted in less overall guidance for the PSTs and more reliance on their assigned engineering partner.

What we learned was that some UESs provided excellent support to the PSTs, while a few engineering students struggled with the project due to outside conflicts that were sometimes COVID-related. PSTs partnered with underperforming UESs were challenged to assume additional responsibilities and guide their 5th grader to completion independently. Those who managed successfully often gained confidence. One PST explained:

> After realizing I was not going to have the engineering partner with me in-person to help with the coding, I was definitely not confident that I would be able to accomplish much with this project. But once I started working on my own, I realized it wasn't so bad and gained confidence after learning to do it on my own.

Another PST, however, required intervention from a faculty member to assist her 5th grade partner when her UES was unresponsive. In general, PSTs responded well to support from faculty. This was especially true when encouragement was provided in the context of autonomy. One PST explained that her instructor "really encouraged us that it was okay to learn with our students. That we weren't expected to know everything. And I think that that gave me some confidence to be willing to try out some new things technology-wise." This supports Kaplan-Rakowski's (2020) assertion that emotional support should be prioritized over efficiency of learning especially when the world is rapidly shifting to online learning during a global pandemic. The need for additional emotional support during this time is attributed to the impact that the pandemic had in exacerbating mental health conditions, such as depression and anxiety, in both adults and children alike (Rajkumar, 2020). Another PST explained how the limited guidance from faculty inspired her to exert more effort in her preparation:

> We only got a certain amount of instruction. So, I feel like a lot of this project was, kinda, up to the students to, kinda, figure out. So... I was googling, like, making sure I had the right definitions, and everything made sense because I didn't wanna go and teach my students something that was incorrect.

LESSONS LEARNED FOR RESEARCH

Much of the research in online education has focused on developing and evaluating technologies to enhance online learning. However, our experience with PSTs in 2020 suggests that teacher educators need to focus on developing and evaluating opportunities for online teaching. More specifically, research is needed to identify successful strategies for PSTs to interact virtually with K-12 students, both synchronously and asynchronously, and to evaluate the impact of those interactions on PSTs' learning. If teacher educators rely exclusively on formal field placements to provide these opportunities, there is little chance that PSTs will have the experience they need for a post-COVID-19 educational reality. A research agenda calling for innovative approaches to providing virtual teaching experiences is imperative.

To this end, we propose research into PST participation in the creation of asynchronous instructional materials, such as virtual field trips, simulations, and other media-rich presentations; PST interaction with K-12 students via asynchronous tools (e.g., Seesaw, Flipgrid, Quizizz); and PST participation in synchronous instructional exchanges, especially lessons delivered with web-based meetings tools (e.g., Zoom) and instructor-paced presentation tools (e.g., PearDeck). In methods classes and instructional technology courses, PSTs are often asked to create lesson resources that are never leveraged with K-12 students. The PSTs' experiences in our Spring 2020 implementation are a reminder of the motivational and learning benefits of PSTs' direct interaction with K-12 students. We call upon teacher educators to organize class-based virtual field experiences that provide an authentic K-12 audience for PSTs' learning artifacts. Such experiences can occur both during and after school and in both formal and informal contexts and can serve a dual purpose: to provide personalized virtual interaction for K-12 students and to provide PSTs with meaningful online teaching experience.

Finally, as a follow up to the PSTs' reflections shared here, we suggest that more research is needed to understand how to structure PSTs' online teaching experiences in order to provide a continuum of autonomy that PSTs can access based on their confidence level. While all students are likely to benefit from some degree of autonomy, students with more confidence may be better positioned to benefit from greater freedom in their design of online interactions with K-12 students, whereas less confident PSTs may benefit from greater structure. Research is needed in order to understand how to appropriately scaffold PSTs' virtual field experiences.

LESSONS LEARNED FOR PRACTICE

Many teacher educators advocate for preparing PSTs for online teaching; however, a large number of teacher educators continue to promote face-to-face rather than online experiences (Kennedy & Archambault, 2012). However, the findings from our project as well as those documented by other researchers (Kier & Clark, 2020; Koch & Vu, 2020) assert that teacher educators can, and should, provide meaningful opportunities for PSTs to interact virtually with K-12 students, even post-COVID-19. By ignoring this often untapped, rich resource, teacher educators preclude worthwhile field experiences. Mishra and Koehler (2006) defined the technological pedagogical content knowledge (TPACK) teachers require to effectively utilize educational technology, but recent research suggests PSTs lack sufficient TPACK (Wang et al., 2018). It is the responsibility of teacher educators to organize and establish effective virtual field experiences to cultivate this knowledge in PSTs.

The intention of this chapter is to shed light on the benefits and challenges of synchronous and asynchronous field experiences, to add to the literature about PSTs' experiences with these methods, and to offer suggestions on how teacher educators can structure them. Our experience in Spring 2020 found that *asynchronous* field experience with elementary students helped PSTs:

- Learn how to create engaging presentations for asynchronous interaction;
- Gain experience with educational technology tools (e.g., Google Suite products, Kahoot);
- Develop pedagogical strategies for online learning (e.g., ways to maintain student engagement);
- Consider equity issues regarding resources (both digital and physical); and
- Practice effective virtual communication and collaboration with project team members and faculty.

Synchronous one-on-one collaboration with elementary students provided a unique opportunity for PSTs to gain technical expertise and pedagogical knowledge, both generally, and specific to online teaching. PSTs found their interactions with elementary students motivating and beneficial. Specifically, they:

- Gained experience with educational tech tools (e.g., Zoom, navigating multiple platforms);
- Learned how to support and foster elementary students' independence;
- Gained appreciation for learning alongside students; and
- Gained valuable STEM skills.

Our Spring 2020 experience indicated that PSTs gained valuable skills while preparing for and teaching asynchronous and synchronous engineering lessons and developed different skills in each context. Thus, we suggest that teacher educators prepare PSTs to utilize both types of online interaction.

The Ed+gineering project successfully guided PSTs in transitioning hands-on engineering lessons to virtual learning experiences for elementary students by providing them with adequate resources and support. We offer the following suggestions for structuring virtual field experiences based on our experience from Spring 2020:

1) Leverage the motivational power of interactions with K-12 students. Our PSTs were energized by their interactions with youth, and this energy focused their attention on lesson preparation. We recommend designing field experiences to maximize the potential for back and forth interaction between PSTs and K-12 students. PSTs benefit from understanding how well their instructional materials meet the needs of their intended audience.
2) Allow PSTs to make instructional decisions. Our PSTs benefitted from exploring issues of equity in relation to determining the supplies K-12 students would use in their engineering designs; structuring lessons to address students' interests and needs; and troubleshooting emergent concerns. In our experience, allowing PSTs autonomy and ownership in deciding the materials for their lesson were likely to inspire greater investment in their lesson preparations.
3) Model online instruction, but provide space for PSTs to make non-trivial decisions as explained above. Our experience suggested that the PSTs early in their programs appreciated and benefitted from the lesson templates we provided, while our more experienced PSTs were ready for more creative freedom.
4) Structure virtual field experiences to enable support from peers as well as instructors. Our PSTs drew upon support from their teammates as they ventured into the new experience of teaching online. If we had to provide individual support for all of our PSTs, our task would have proven far more challenging. PSTs benefited from seeing product examples from their teammates and faculty and were encouraged by interactions with engineering and elementary student partners. Through these experiences, PSTs who initially felt overwhelmed by the task developed increased confidence and competence.

If virtual field experiences can be designed intentionally with consideration of the potential challenges and benefits of online teaching interactions, rather than quickly adapted in response to a pandemic, they offer tremendous potential for PST learning and confidence building. Furthermore, the integration of virtual field experiences into teacher preparation will produce a cadre of teachers much better prepared for virtual schooling to meet future needs.

WHAT YOU SHOULD READ

1. Larson, J. S., & Archambault, L. (2019). The Extent of K-12 Online Teacher Development: A Disconnect Between Preparation and Practice. In Heafner, T. L., Hartshorne, R., & Thripp, R. (Ed.), Handbook of Research on Emerging Practices and Methods for K-12 Online and Blended Learning (pp. 57-77). IGI Global. http://doi:10.4018/978-1-5225-8009-6.ch003
2. Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020, March 27). The Difference Between Emergency Remote Teaching and Online Learning. Educause Review. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning
3. Ferdig, R. E., Baumgartner, E., Hartshorne, R., Kaplan-Rakowski, R., & Mouza, C. (Eds.). (2020). Teaching, technology, and teacher education during the COVID-19 pandemic: Stories from the field. Association for the Advancement of Computing in Education.

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