

Applied Environmental Teaching using Caring Pedagogy is Essential in Educational Disruptions

Byung-Yeol Park¹⁾, Rebecca Campbell-Montalvo¹⁾, Todd Campbell¹⁾, Hannah Cooke¹⁾,
Oxana Sidorova²⁾, Chester Arnold³⁾, Maria Chrysochoou⁴⁾, Peter Diplock⁵⁾

1) Department of Curriculum & Instruction, Neag School of Education, University of Connecticut, Storrs, CT, USA

2) El Instituto, University of Connecticut, Storrs, CT, USA

3) Center for Land Use Education and Research (CLEAR), University of Connecticut, Storrs, CT, USA

4) Civil and Environmental Engineering, School of Engineering, University of Connecticut, Storrs, CT, USA

5) Center for Excellence in Teaching and Learning, University of Connecticut, Storrs, CT, USA

Abstract

Applied pedagogy, and specifically service learning, bridges the university educational experience with hands-on training. Such pedagogies in STEM are nuanced in unique ways in comparison to more classroom-based STEM learning and applied teaching outside of STEM contexts. As STEM service learning may be especially vulnerable during system shocks, we advance work on such pedagogy by investigating how a certain type of pedagogy, specifically caring pedagogy, may be particularly useful during social disruption (i.e., COVID-19) in applied STEM learning. The main purpose of this study is to examine how pandemic-related disruptions impacted teaching and learning in a service-learning STEM program known as the Environment Corps. We thematically analyzed longitudinal data from multiple rounds of interviews with seven instructors, one-time interviews with thirteen undergraduates, and eight instructor meetings occurring from late 2019 to early 2021. Similar to findings in related work, teaching and learning obstacles from the pandemic were personal, interpersonal, and logistical. After

instructors realized they needed to implement changes, some obstacles were ameliorated through caring pedagogy practices outside of in-person interaction. Yet, even as disruptions lessened, students and faculty still experienced impacts from the pandemic. We offer insight into how applied STEM courses can be adjusted with an eye toward caring pedagogy-informed practices to minimize negative effects from system shocks. This contributes to the literature on disaster and COVID-19-related challenges, caring pedagogy in virtual spaces in teaching circumstances, and environmental education.

Keywords: applied STEM education, caring pedagogy, environmental education, pandemic, remote or virtual schooling, service-learning

Introduction

Environment Corps¹ (E-Corps) is an interdisciplinary environmental sustainability service-learning program at a large New England public university that primarily uses applied case studies (see Arnold et al., 2021; Campbell-Montalvo et al., 2021; Cooke et al., 2023; Park et al., 2022). Service-learning programs have been shown to be beneficial to students, in that one generally “fosters student engagement, improves retention, helps to strengthen civic responsibility, and develops critical thinking” (Veyvoda & Van Cleave, 2020, p. 1544). Such programs also have crucial community outcomes in helping municipalities bridge skill gaps to address environmental concerns (Arnold et al., 2021). Unfortunately, STEM service-learning programs are susceptible to disruption and dysfunction during times of social disruption, including the COVID-19 pandemic and school closures. Given the importance of such programming, and that a longer-term investigation of the implementation of the E-Corps program was underway prior to the pandemic, we adjusted research protocols to capture COVID-19-related concerns in E-Corps.

In this manuscript, we outline the teaching and learning obstacles faced in E-Corps, discuss strategies used to mitigate those obstacles, and share outcomes of such efforts. Interview and observation data was thematically analyzed, and expressive support (Puccia et al., 2021) attuned to emotional empathy, accommodations, and caring was a key theme in the data. We

¹ Learn more about E-Corps: [<https://ecorps.initiative.uconn.edu>].

therefore adopted a lens of caring pedagogy, an approach centering the importance of student environments on teaching and learning. This extends work on caring pedagogy to the nexus of scholarship on applied STEM learning and social disruption. We pay special attention to the change in faculty mindset when it became apparent the pandemic was not ending in mid-2020, as well as the emotional work characteristic of caring pedagogy implemented by faculty. The research questions that drove the present study included:

1. How was teaching and learning in E-Corps affected by the pandemic?
2. How did faculty orientation to planning and pedagogy change throughout the course of the pandemic?
3. What pedagogical strategies did instructors implement to address teaching and learning obstacles?

To provide additional background on E-Corps, its purpose is to improve student applied skills and help local communities address environmental concerns they face (Lin & Shek, 2021). There are presently three E-Corps courses, Brownfields, Climate Change, and Stormwater, and each is taught by two to three faculty members. Each course uses a two-semester sequence with the first being knowledge-based and the second applied, during which community group projects are undertaken using an applied case study approach. From its inception in 2017, E-Corps has enrolled 504 students from 22 majors, including environmental engineering, landscape architecture, and urban and community studies. Student teams have worked with 60+ Connecticut towns and organizations on 140 projects with a wide range of deliverables. Many of the projects have set the stage for leveraging funding for the towns, for instance, towns participating in the Brownfields Corps have been awarded a collective \$4.5 million in grant funding from the Environmental Protection Agency.

All three E-Corps courses were underway when COVID-19 was declared a pandemic in March 2020 (World Health Organization, 2020). Like educational programs elsewhere (Collier et al., 2022), the E-Corps program and the university in which it is housed transitioned from in-person learning to online education. Given their design, the success of service-learning efforts like E-Corps can be particularly threatened during system shocks, such as pandemics, environmental disasters, social strife, and other events that result in structural changes disrupting how education is delivered (DiCarlo et al., 2007; Palmer et al., 2021; Verma et al., 2020). How

instructors pivot their courses during such changes influences students' personal growth and course-related learning outcomes (Adkins-Jablonsky et al., 2021; Doody et al., 2020).

Literature related to natural disasters (e.g., earthquakes/seismic events, hurricanes, flooding), including the pandemic (Miller et al., 2021), with a focus on their emotional, personal, and interpersonal effects (Akyıldız, 2020), technical challenges (Irfan et al., 2020; Lederman, 2020; Onyema et al., 2020; Williamson et al., 2020), and public buildings closures (UNESCO, 2020) offers insight on how schools and programs may have experienced and weathered the pandemic. The COVID-19 pandemic has impacted the teaching and learning environment and a myriad of other social factors affecting schooling. In this context, we recognized the importance of carefully investigating disruptions connected to natural disasters and saw the COVID-19 pandemic as an informative case that could provide us insight into how teachers and students experienced and negotiated challenges they experienced.

Literature review

Disruption in Education

Previous research on education within the context of disasters has focused on regions across the globe and covered a wide range of disruptions, such as seismic events (Ayebi-Arthur, 2017), hurricanes (DiCarlo et al., 2007), war (Rajab, 2018), and, more recently, the COVID-19 pandemic (Adkins-Jablonsky et al., 2021; Bozkurt et al., 2022; Doody et al., 2020; Gin et al., 2021; Miller et al., 2021; Moorhouse & Tiet, 2021; Oprysko, 2020; Reimers & Schleicher, 2020; Verma et al., 2020; Veyvoda & Van Cleave, 2020). This work has delved into specific obstacles these disruptions caused (i.e., cancelled class meetings/contact hours, movement to online classes), as well as the pedagogical practices (i.e., consistent communication, opportunities for make-up contact hours, increasing learner autonomy) used by educators to deal with these events. Cancelled in-person classes and movement to online or remote learning has thus been documented as a general educational obstacle during disasters.

Recent research on COVID-19, specifically in education, highlights the similar and different obstacles that occur during pandemics, in comparison to characteristics of other events. Much COVID-19 education research has focused on the social and emotional challenges. For example, in the early months of the pandemic, many countries closed their national borders and/or restricted travel, ordering people to shelter at home (Oprysko, 2020; Verma et al., 2020). Many businesses were shuttered, events canceled, workforce restrictions enacted, employment

reduced, and childcare discontinued. In-person learning ended as governments closed school buildings (Reimers & Schleicher, 2020). As a result, students were negatively affected emotionally and mentally, experiencing anxiety, despair, and boredom as well as feelings of isolation originating from a lack of interaction and communication with others (Akyıldız, 2020; Bozkurt et al., 2022). At the same time, students lived in families dealing with higher rates of unemployment (UNESCO, 2020) and worried about themselves or their families contracting COVID-19 and becoming ill (Arriaza et al., 2021; Gin et al., 2021; Son et al., 2020).

Caring Pedagogy

Caring pedagogy is the art of teaching that addresses the environmental factors affecting student learning. This includes support for learners' emotional, psychological, social, personal, or interpersonal needs as well as engagement of learners in meaningful learning activities (Duffy, 2018; Hills & Watson, 2011; Rio Poncela et al., 2021; Soto, 2005). Noddings (1995) highlighted caring pedagogy that plays an important role in connecting students and subjects to existential questions and creating personal relationships between people. Highlighting the importance of recognizing the vulnerability of students' learning in a school context, she highlighted teachers' professional ability in making decisions in response to students' needs and anticipating possible problems that may disrupt students' learning (Noddings, 1995, 2012).

Examples of caring pedagogy practices include "(a) engagement in reciprocal, transpersonal caring relationships, (b) sustainment of safe, culturally responsive, and structurally accessible learning spaces, (c) use of inclusive and strength-based teaching practices, [and] (d) cultivation of flourishing and meaningful student learning" (Christopher et al., 2020, p. 824). For example, Christopher et al. (2020) offer an extensive explanation of caring pedagogy in nursing programs, noting the importance of co-presence or in-person encounters in caring pedagogy.

Researchers have identified germane pedagogical practices that address educational obstacles during disruptions such as COVID-19. Generally, making changes in pedagogy (e.g., mobilizing good communication practices) often led to improved emotional outcomes, such as increased feelings of support among colleagues, increased adaptiveness in teaching, and the creation of digital tools that save time (Adkins-Jablonsky et al., 2021; Dohaney et al., 2020; Doody et al., 2020; Miller et al., 2021). More specifically, researchers have shown the importance of educational caring work during the pandemic lockdown, focusing on teachers' perceptions, the supports and challenges that exist, and the need to understand and support

students' personal situations (Arriaza et al., 2021; Manier et al., 2022; Moorhouse & Tiet, 2021; Rio Poncela et al., 2021). Yet, overall, there is a lack of recognition of caring (Rio Poncela et al., 2021), and how the pandemic disruptions differently affected teaching and learning (Moorhouse & Tiet, 2021).

In its concern with students' learning environment and the emotion work done to address it, caring pedagogy is an appropriate theoretical frame to situate our work given the impacts of the pandemic on the delivery mode and social context of education. Institutions implementing caring pedagogy were being tested throughout the COVID-19 pandemic (Bozkurt et al., 2022; Moorhouse & Tiet, 2021), but there are still few examples of how educational changes were made to sustain caring pedagogies, especially in STEM service-learning contexts. Our work uncovers how caring pedagogy, traditionally dependent upon in-person interactions, can be continued in times during the disruption of in-person schooling. Therefore, in our investigation of the effects of the pandemic on environmental sustainability service-learning courses, we build upon previous studies on how obstacles caused by disasters and the COVID-19 pandemic were addressed, using caring pedagogy as a framework to analyze instructor and student experiences.

Methods

Context

As noted, the Environment Corps (E-Corps) program includes three environmental service-learning courses (i.e., Brownfield Corps, Climate Corps, and Stormwater Corps) that were and are currently taught at a public research university in the northeast United States. In the first semester, students are provided with learning opportunities through investigating real-world scenarios to understand the local impacts and implications of environmental issues and suggest possible solutions. For this, students engage by collaborating in small groups, searching relevant research articles, and attending guest lectures from community representatives or subject matter experts. In the second semester, students apply what they learn from the classroom semester to service-learning projects to address environmental challenges in collaboration with community members. Within this program context, we framed our analysis of instructors' caring pedagogy efforts in Design Based Implementation Research (DBIR). We mobilize this supplementary frame because the articulated approach for the larger E-Corps educational arm of the program was guided by four principles of DBIR: "(a) a focus on persistent problems of practice from multiple stakeholders' perspectives, (b) a commitment to iterative, collaborative design, (c) a

concern with developing theory and knowledge related to both classroom learning and implementation through systematic inquiry, and (d) a concern with developing capacity for sustaining change in systems” (Fishman et al., 2013, pp.142-143). When considering supports for classroom learning, we mainly focused on the role of instructors’ pedagogical caring practices to address obstacles and sustain students’ learning during the pandemic.

Participants

The seven instructors who offered the three environmental service-learning courses participated in data collection and supported the recruitment of student interviewees. In addition to the faculty, three staff members in the administrator team and four education researchers participated in the faculty meeting as stakeholders. The faculty meeting group consisted of 93% white and 7% Asian participants, with 57% being men and 43% women. For the student participants, the recruitment pool consisted of 134 students from a diversity of majors (e.g., agriculture, economics, engineering, etc.) enrolled in the courses during the three semesters (i.e., Fall 2019, Spring 2020, and Fall 2020). Within the pool, we identified a range of students who were willing to share their course experiences. In the end, thirteen students participated in the interview for data collection. These students are more racially diverse than the instructor meeting pool, including multiple African American as well as white presenting participants, but as race/ethnicity was not recorded due to a design limitation, we are unable to report these figures specifically. In addition, the signed consent forms were collected from all participants before the data collection. More details about the course participants can be seen in Table 1.

Table 1

The number of instructors and student enrollment for each of the E-Corps course

E-Corps Courses	Fall 2019	Spring 2020	Fall 2020
Brownfield Corps (two instructors)	23 students	11 students (5 projects)	30 students
Climate Corps (two instructors)	21 students	12 students (3 projects)	24 students
Stormwater Corps (three instructors)		9 students	4 students (4 projects)

Data Collection

From the second half of 2019 to the end of 2020 academic year, we conducted three semesters of interviews with E-Corps students and faculty and observed faculty meetings. Interviews were conducted using pre-existing IRB-approved interview protocols that contained items measuring student and faculty course experiences, including challenges, successes, and teaching and learning strategies related to both instructional planning and learner engagement. The interview protocol also included questions about their experiences as part of community projects. Three rounds of faculty interviews with the seven faculty members were done in dyads or triads grouped by course (i.e., one interview with the two Climate instructors together, one with the two Brownfields instructors, and one with the three Stormwater instructors). Aside from one pair of students, twelve one-time, individual student interviews were conducted during the semester (typically near the end) in which they were enrolled in an E-Corps course.

From the second half of 2019 to the first quarter year of 2021, the eight faculty meetings held with the seven faculty and additional E-Corp program members, such as representatives from Center for Excellence in Teaching and Learning, were observed. All data were audio recorded and transcribed. Additional details of data collection method, participants, and sources can be seen in Table 2.

Table 2

Data collection methods, participants, and data sources

Data Collection Methods	Times and Type of Participants	Data Sources
Instructor interviews	8 times with 7 instructors	2 faculty from Brownfields: Fall 2019; Spring 2020; Fall 2020
		2 faculty from Climate: Fall 2019; Spring 2020; Fall 2020 3 faculty from Stormwater: Spring 2020; Fall 2020
Student interviews	12 times with 13 students	1 student from Brownfields: Fall 2019
		2 students from Climate: Fall 2019
		2 students (as a team) from Brownfields: Spring 2020
		1 student from Stormwater: Spring 2020 1 student from Climate: Spring 2020

		2 students from Stormwater: Fall 2020
		2 students from Brownfields: Fall 2020
		2 students from Climate: Fall 2020
		2 times in Fall 2019
Project meeting	8 times	2 times in Spring 2020
observations	with 13 faculty, administrators, etc.	1 time in Summer 2020
		3 times in Fall 2020

Data Analysis

Focusing on pedagogical practices embraced in the framework of caring pedagogy, data from faculty and student interviews and faculty meeting observations were analyzed to identify the obstacles students and faculty experienced and how they addressed them. We used thematic analysis (Braun & Clarke, 2006) with a codebook we created related to our research questions to analyze this qualitative data. Developed codes were aggregated within the following themes: (a) perceptions on E-Corps classes, (b) high leverage practices, (c) institutionalization, (d) other, and (e) COVID-19. For this study, we focused on the COVID-19 related codes (see Appendix A). To achieve an acceptable intercoder reliability percentage (O'Connor & Joffe, 2020), we compared agreement on primary codes between three raters and found an average agreement across the raters of 82%, which is above the 80% that is often considered acceptable (Krippendorff, 2003; Landis & Koch, 1977). In concert with the research questions and key concepts, data from codes were organized and are presented in the refined topics and subthemes shown in the following findings section. All participants' names used throughout the findings are pseudonyms.

Findings

Thematic analysis revealed that a range of challenges and successes were experienced by students and faculty. First, we divide the obstacles faced into three types: personal, interpersonal, and/or logistical (i.e., resulting from the state's stay-at-home order/closure of public buildings). Second, we found instructors changed their mindset of the situation they were in over time. Third, this change led to their implementation of pedagogical practices we organize into three types: increasing structure, changing the format of activities, and expanding a culture of support. Further details about each of these themes are described in the following sections.

Obstacles

There was a marked impact of COVID-19 on teaching and learning in E-Corps courses. Both students and faculty faced obstacles related to the educational environment specific to

service learning and environmental sustainability, as well as obstacles more generally faced by any course that was forced to move from in-person learning to online learning.

Personal Obstacles

Two main personal obstacles were students' chaotic home environments and lack of focus:

- Students and instructors reported that learning online was a task in and of itself for which intense focus was needed by students but not always available.
- Focus was threatened in part by hectic household settings, including the need to care for family members.

Regarding non-voluntary online learning being an added obstacle in itself, during her interview, Brownfields student Jennifer said, "It seemed like I was doing so much more homework, but in reality, I was just attending lectures. ... Being at home was always having distractions in the background." In discussing an inability to focus as an obstacle, Brownfields student Jack pointed out the difficulty in learning online during the pandemic, "If you're in a WebEx meeting and someone's giving a presentation and your camera isn't on, you might get distracted." Climate student Harmony also thought that being online could make it easier not to participate:

Students didn't want to interact. Nobody had their cameras on. Except for maybe one student, it was just the professors. It's easier for people not to show up when it's on WebEx than in person.

Brownfields instructor Penelope also noticed that students could become disengaged:

Students may be more tempted to skip the lecture and not realize that a lot of the knowledge comes from the presentations. The students don't necessarily make the direct connection of how that knowledge feeds into the projects. In the remote environment, it's a lot harder to make sure that connection happens.

Penelope's explanation of how not being fully engaged in class introduces an additional layer of difficulty to completing course projects, which the E-Corps programming is centered around.

In addition to these impacts of involuntary online learning, the chaotic household background experienced by students was an additional stressor to trying to learn online. Brownfields student Kadina noted that preparing a workspace at home and ensuring that the

internet connection was solid were new steps that needed to be considered. The context of the household underpinned these issues:

Definitely a lot more focus is needed. You have to set up your computer and make sure all the connections are good and just solely focus on the lecture for an hour without worrying about your family running around.

Caring for household members suffering from COVID-19 also presented problems. Climate instructor Elisabeth noted in an E-Corp faculty meeting, “There were a number of students dealing with COVID-19 issues in their families or in general. Every student had individual circumstances, whether it was having parents or relatives who were sick, or treating people, or somehow [being] very directly involved.” Together, these two themes show the importance of challenges for new, involuntary online learners, such as the effects of an inability to focus and chaotic households, on applied STEM learning contexts.

Interpersonal Obstacles

Aside from having difficulty concentrating in online classes in tumultuous household settings, students and faculty often discussed the drawbacks of learning outside of physical co-presence with peers and instructors. There were three main impacts on students and faculty:

- an initial decrease of individual support students received from instructors,
- a beginning of a decline of relationships between students and faculty as well as among students, and
- students’ challenges in doing group work.

In terms of an initial decrease of perceived support, Climate student Nisha noted that it was difficult to get one-on-one support from her instructors online.

COVID-19 happened, and I started to doubt my ability to do the project, mostly it was more of a personal thing—of not being able to have that in-person support. It’s something that I really need. Online support doesn’t really work for me in the same way.

Similarly, at the end of the first semester when classes moved online midway through, Climate instructor Elisabeth discussed the difficulty she had in providing support and feedback in a written fashion. This was especially difficult since she was accustomed to delivering it via in-person conversations with students:

When students submitted papers, it was so time-consuming to send them a reply with comments. We didn’t do it online, we didn’t have time to figure that out.

The involuntary move online affected relationship building and diminished opportunities for spontaneous interactions among students and instructors. Such interactions were previously a time when professors provided specialized learning. For example, Brownfields instructor Penelope noted that students did not benefit as much from the interaction with professional guest speakers when classes were online as they did the past when classes were held in person:

Students missed out on the interactions with professionals. Before, you would see three or four students approaching the presenter, having a side conversation, following up with them, having that more interactive [discussion], or asking questions. Now, there still are some questions [after online presentations] but students don't get the same level of connection.

More common than conversations with speakers, engagement and relationship building opportunities between students and professors seemed to suffer the most initially. Climate instructor Scott shared, "I personally miss the in-person connection with the students—I think we're able to be more responsive to the students' needs and better understand students' interests personally [when we're in co-presence]."

Getting student groups to work together well seemed to be particularly difficult. Brownfields instructor Phaedra explained how the option to participate online in her hybrid course affected students' interaction and engagement:

I had three students entirely online doing the project. They had some trouble at keeping up and they were a little bit less engaged, compared to the other students that were in person. We have some students that were sometimes online, sometimes in person due to different quarantine periods that they have to follow.

Brownfields instructor Penelope also noticed that her online groups "were less able to connect with each other." Penelope and Phaedra felt the online student teams were disjointed and not working in tandem as well as they did when they were in person.

Accordingly, a common reason that participants cited in the difficulty to perform group work stemmed from struggles to get everyone on the same page—with participants specifically noting how COVID-19 and involuntary online learning had an impact. For example, Brownfields student Jack discussed difficulties in scheduling meeting times with group members, "It's hard to wrangle everybody to get on their computer at the same time." Brownfields student Alicia elucidated:

When it comes to projects...it's multifaceted. [Learning online] changes the amount of people that you're working with and the different types of work that go into it. My biggest struggle was just communicating with the group and to make sure that we were all on task for the same point.

Connecting this to the importance of the household context, Brownfields student Jack discussed the difficulties in collaborating online, "I like to be face-to-face with people and it's a lot easier to engage with them...People don't get distracted by something going on in their house or wherever they may be."

Thus, a lack of co-presence, surely in combination with other stressors, had effects on students, reducing their opportunities for interpersonal interactions. This led to decreased confidence and feelings of support, less relationship building, and increased stress in group work. These effects are particularly troublesome given that group work is a hallmark of STEM education and the E-Corps' programming.

Logistical Obstacles

The inability to visit field sites presented additional obstacles to teaching and learning quite specific to the service-learning context. There were three main ways that logistical obstacles were a problem:

- they prevented access to the communities informing the group projects,
- they hindered students' abilities to learn professional skills (such as the ability to visually inspect and classify a site as a brownfield), and
- they prohibited students from accessing resources such as records and software needed for the projects.

For example, Brownfields student Alicia noted that not being able to visit sites was a main problem she encountered in E-Corps, "Honestly, COVID-19 has been the hardest challenge to overcome ... we can't meet in person or suddenly visit any of these sites." Climate student Nisha mentioned that not being able to go to field sites impacted students' access to community information about the site crucial for their projects:

We were supposed to go to the marinas. Because of COVID-19, we weren't able to go. I was looking to ask the lady there what things tend to flood if there was a rainstorm, what things generate the most income for them.

It also became more difficult to make sure that the projects were appropriate for the population they served. Brownfields student Jennifer commented on the importance of communicating with their town's community, which had a median age of 50-60 years old: "We didn't have as much of an access to the community. It would have been more important to get their opinions after we had done most of the inventory." Brownfields instructor Phaedra noted that this inability to visit sites also decreased students' feelings of connectedness to the projects, "The interaction with the town was not the same since we didn't visit the town to see the problem sites, all the meetings were through Webex."

Aside from missing out on learning about the communities, students' mastery of technical skills was also threatened by not being able to experience the sites in person. For example, Stormwater instructor Paul articulated how not being able to go out into the field during COVID-19 affected skill development:

A lot of time, you do lose something by not being out there. I think that it was hard not having that outdoor discussion where it's much more interactive. It's really important for them to be out in the field and understand that everything they've learned up to that point...Analyzing these sites via Google Maps, and CT ECO [a statewide environmental mapping website], and other online mapping systems, is all moderated by the reality on the ground. That's not something they're going to learn until they actually go out in the field.

In addition, the closure of buildings affected students' abilities to access resources needed in this applied STEM context. For instance, Brownfields instructor Penelope discussed the effects of the shuttering of government buildings where records are stored, "We were planning to have visits to the DEEP [Department of Energy and Environmental Protection] file room to search environmental records but we couldn't do it." Additionally, the closure of public buildings meant that students could not access state-of-the-art computers or specialized programs in campus labs. Climate student Nisha shared:

The software that I was using works better on a desktop computer with a bigger processor. Using it on my laptop was something completely different because I was also using the university's AnyWare Software. It made things a lot slower.

Stormwater instructor Wes similarly noted that because the on-campus computer lab was closed, “Students who had a Macintosh at home could not do GIS [Geographic Information System]-related project components given that GIS requires a Windows operating system.”

Thus, the closure of public buildings affected teaching and learning in ways quite specific to the applied STEM context. With the E-Corps courses being project focused, having reduced access to the community, skill development, and resources hindered teaching and learning in many ways.

Changes in Faculty Orientation to Teaching

While these obstacles indeed impacted teaching and learning, many of them were ameliorated to differing degrees through pedagogical practices. However, initially, instructors’ approaches to the E-Corps classes during the beginning of 2020 were reactive and immediate. Stormwater instructor Wes explained how he and his colleagues reactively changed their plans for the second half of the spring 2020 semester to make it conducive to online learning:

We redesigned all those exercises for them to do individually, to do something similar as what we’d planned [for group projects] but would be able to be done by an individual. That included the final project.

As time went on throughout summer 2020, it became clearer that the pandemic would continue, and instructors started to express statements indicating their changing orientation to course planning. When thinking about how he could pivot his class in May 2020, Climate instructor Scott shared, “We are asking ourselves, ‘What are we going to change the next semester if we have to do it online and change the curriculum?’” A few months later, at the August 2020 team meeting, Climate instructor Elisabeth provided details about the changes she and Scott made for their online course, “We’ve spent the summer re-working assignments and instead of giving a mid-term exam, we have a mid-term project. Scott is re-working some of the other projects that we have, so it’s just been re-tooling it to go online.”

While there was uncertainty and changing regulations throughout 2020 and 2021, E-Corps instructors’ orientation to the changes showed that they had accepted that there were some things lost, but over time they adjusted, and outcomes improved. For instance, during a January 2021 interview, Brownfields instructor Penelope commented, “We achieved the same objectives that we achieve every other semester. Not as ideally, but still achieved.”

Pedagogical Practices

These changed practices became more refined over time, coming about from a change in instructor mindset from shock at the disruption to active adaption. The caring practices centered around increasing structure to promote communication and relationships in support of projects, changing assignments and activities to match the online medium and be lower stress in response to the chaotic home environment, and creating a stable culture of support for students.

Increase of Structure

Instructors employed several specific changes in practices that subsequently made the projects “equally good”, as Brownfields instructor Penelope said, and greatly mitigated many obstacles encountered. These changes centered around:

- amplifying structured aspects of their in-person courses that could also work well online, including more guidance with the projects,
- providing activities or short quizzes after lecture or guest speakers to promote engagement during the presentations,
- having additional review or extra, multi-modal provision of course information, and
- supporting students to promote interaction within their groups.

In terms of the added guidance, Penelope articulated that she felt that having the course organized around a structured, community applied project drove success:

The fact that this is community driven, with a project—a specific deliverable. There’s a deadline and a clear framework. Students were like, ‘Oh, the town is waiting for our work.’

Climate instructor Scott noted that he used a general Scope of Work document to help establish that structured framework, decreasing potential uncertainty in the project:

This semester, we’re having the students prepare a Scope of Work for the projects. We’re going to have that approved by the community, so that there’s no doubt about what students are doing. It’s going to be done by email. Something in writing helps knowing what the expectations are so there’s no ambiguity.

Climate instructor Elisabeth agreed, noting further support of the structured framework by having students “turn in a log of their interactions with the community. Whether it’s phone calls, emails, and just a sentence or two as to what was discussed, what came out of it.”

To address the ease at which students become distracted when learning through WebEx, especially with cameras off, instructors made additional changes. For example, Brownfields instructors began having short quizzes after lecture, which improved student engagement:

We added three questions, short quizzes after the guest lectures, to keep the students engaged. ... They were paying attention to what the professional was saying because they were interested in the subject, but also they knew that a quiz is coming after that.

Another common strategy that instructors described as being useful during teaching in the pandemic was explaining things more than once, or increased review and information provision. Climate instructor Elisabeth commented, “We spent a huge amount of time on the assignments and detailing exactly what we wanted [and providing] rubrics. They got it written, they got it orally from us, repeatedly.”

While students and instructors early in the pandemic described the challenges with group work, a strategy that Brownfields students and instructors noted was successful involved more concerted supporting students in their group work. For example, Brownfields instructor Penelope noted how her course earmarked one of the two class meetings each week for group meeting time, “We meet with students once a week. The groups meet in the second slot reserved for class. It is easier to coordinate.” Brownfields student Kadina agreed that the strategy was useful:

We meet for half an hour every Thursday just to go over what we’d done for the week, what we should do for the next week, any other upcoming plans. Then for the town meeting, we all called into some chat room and just talked over the phone, including the class Teaching Assistant as well as all the people from the town committee.

Thus, these varied structural changes provided students with more guidance and feelings of security because they knew what to expect and were supported through structured activities.

Change in Format of Assignments and Activities

In addition to increasing structure to address obstacles, the instructors also made changes that can be directly linked to the obstacles that were being faced. They:

- moved the format of assignments away from tests,
- augmented the scope and goal of individual projects on a case-by-case basis,
- created interactive site tours and virtual community visits.

For example, to address the hectic household environment and accompanying student stress, most E-Corps instructors switched from exams to other activities. Climate instructor Elisabeth shared:

Instead of giving a midterm exam, we did a midterm activity that read, ‘It’s the year 2050, and [you have to design a commemorative plaque because] there’s been some climate event. You have to explain the event that occurred, it could have been in the past. Then, what was done about it? What were the impacts? What was the solution?’ It was, ‘Pick anywhere that you want.’

Stormwater instructor Wes similarly pivoted, “We had them do kind of a final activity which wasn’t what we had planned. Now, we think that that’s the best warm-up to the second semester that there is.”

To deal with public building closures, instructors helped students pivot the approach of their projects. Brownfields instructor Penelope shared about how she dealt with the disruption in the students’ project who needed to go to the DEEP file room but could not:

We adjusted by having the students do whatever they could online. They used resources like Google Maps and the town GIS map to create a list of brownfields to be prioritized for remediation. They developed a methodology based on the characteristics and criteria, and the town was very interested in submitting a grant proposal.

Additionally, a beloved aspect of the Stormwater course is the tours the instructors provide to students of the green infrastructure on campus. Because campus was closed, instructors pivoted by hosting live virtual field trips and creating interactive representations of areas with pop-out information, stories, videos, and/or maps known as story maps. Climate student Charlotte described a virtual tour of green infrastructure on campus:

[The tour] was very interesting. They showed us pictures and videos. The person who normally led the tour when class was in person did it for us online and showed us what we would have seen, so it was so very informative and cool.

In addition to live tours, Stormwater instructors recorded site visits for their students. Stormwater instructor Dan described how that unfolded:

We did some video filming in the fields demonstrating how to do these techniques, and brought those videos into the classroom, and uploaded them so they could watch them.

Thus, changing resources and assignment access and formatting helped address obstacles related to building closure and the increased difficulty in paying attention.

Expansion of a Stable Culture of Support

While many of the instructor changes presented thus far more directly supported students' access to instrumental resources (Puccia et al., 2021) to do well in the applied STEM setting, a common theme in participant responses also centered upon instructor changes that had expressive or emotional impacts on students (Arriaza et al., 2021; Puccia et al., 2021; Skvoretz et al., 2020). These caring pedagogy strategies related to

- the creation of a stable culture of support for students in which instructors were consistently understanding and available.

This stable culture of support was evinced for example, when discussing how she altered her course to help students who were dealing with sick family members do well, Climate instructor Elisabeth shared:

[We were] trying to make space for them and say, 'Don't worry about it now, take care of yourself, and then we'll get you back on track.' Almost every class we said, 'We are here for you. Send us your questions, call us up, schedule a meeting.' I think we really tried to be available and to be understanding.

Students' comments triangulated similarly with instructor recollections of their efforts. Climate student Nisha felt supported and empowered in completing coursework, knowing the professor would be there when needed: "I would say the fact that the professors more or less trust us with whatever we're doing. It was more or less, 'If you have any questions, we're here for you but everything else solely falls on you.' I love that." Similarly, Stormwater student Beth described the emotion work of the professors that supported her in the class:

The professors were very encouraging and tried to remind us that it's okay to ask questions. Or if we don't feel comfortable asking in front of the class, that we could meet after class or have another [private] Zoom meeting to ask whatever we needed to.

By providing access to expressive support, in addition to instrumental changes supporting online learning (Manier et al., 2022; Puccia et al., 2021), instructors' changes were effective in mitigating to an extent many of the obstacles to remote learning during the pandemic in E-Corps.

Discussion

Our study extends research on education disruptions related to disasters and COVID-19 by offering a discussion of educational challenges, such as personal and interpersonal effects of distance learning (Akyıldız, 2020) and logistics (UNESCO, 2020), and caring pedagogy interventions within a context of environmentally focused service-learning courses. Our findings connected to obstacles mirror and extend those reported by research that had previously been conducted in contexts outside of applied STEM/service learning (Palmer et al., 2021). We connect these obstacles to caring pedagogy efforts of instructors focused on relationships, learning environments, teaching strategies, and student learning.

Support and flexibility (Arriaza et al., 2021; Dohaney et al., 2020) as well as increased communication (Ayebi-Arthur, 2017; Miller et al., 2021) have been described as characteristics of resilient instructors in other fields within contexts of disruption. Therefore, re-establishing supportive relationships with students and re-creating caring classroom environments as classes moved online would be essential practices that instructors, as active instructional designers, would have to do to support students' learning during the pandemic (Davis et al., 2021; Gonzalez & Poole, 2021). In our case, to help students deal with or overcome personal obstacles to their learning (i.e., hectic households), instructors engaged in caring pedagogy as they cultivated a stable culture of emotional support and accommodated students in completing their coursework by increasing communication and making themselves available to students via various online platforms or changing the format of course activities (i.e., changing an exam to an activity). Instructors also helped students by providing flexibility when logistical obstacles occurred, such as adjustments to the modes of content delivery (e.g., creating virtual tours of green infrastructure on campus) and objectives of students' projects (e.g., developing a methodology for classifying a site as a brownfield) that also helped students take control of their education (Rajab, 2018; Rio Poncela et al., 2021).

A major focus of the pivots made in this research were in response to a concern for the lack of co-presence and how it was identified as impacting interpersonal dynamics (Tang et al., 2021). To address this, increasing structure, changing the format of activities, and offering consistent support resulted in the courses generally comprising a smaller set of activities than prior, and becoming more manageable so that instructors and students both could handle it more

easily. This also supported the creation of feelings of connectedness and interaction between students, between students and faculty, and with the students and community.

These changes align with Dohaney and colleagues' (2020) stated benefits of increased resilience that come from maximizing teaching and technological abilities. Importantly, using emails and videoconferencing increased the number of opportunities for interactions among students, faculty, communities, and professionals to address the lack of co-presence. The use of technology likewise helped address logistical concerns (i.e., disrupted access to DEEP file rooms). In the end, instructors were, like reported by DiCarlo and colleagues (2007), forced to prioritize the key experiences for learners and rapidly negotiate how these could be accomplished in online settings.

Purposive pedagogical practices emerged after faculty recovered from the initial shock of the spring 2020 semester when classes first moved online, and a change in instructor mindset and approach to teaching began emerging in summer 2020. Over time, high rates of student support and focus as well as continued synchronous attendance during class meetings, continued community involvement (e.g., industry and municipal guest speakers), and successful student projects were again maintained in the E-Corps courses. While participants felt the pivot was generally successful, not all elements of applied STEM learning may translate well to online contexts, certainly not without vast investments of effort by all parties and stakeholders.

The patterns of collaborative work between instructors in E-Corps through their adoption of Design Based Implementation Research seem to be closely aligned to how the members of instructional communities of practice in other contexts interacted with each other to provide advice on instruction, share and co-construct materials, and share social and emotional consideration, during the shift to online (Grunspan et al., 2021). This report of similar learning outcomes, while originally not expected, aligns with results reported by other researchers investigating disaster-related education disruptions (DiCarlo et al., 2007). We highlight that the period of change in instructor mindset should not be overlooked and must be accounted for in future scholarship and practice. Specifically, mindset change exerts a real cognitive burden requiring time and support during transition periods when new programming is implemented or we are asking faculty and students to adjust to immense structural and social changes, particularly in a short amount of time.

Conclusion

The COVID-19 pandemic is not the first major disruption to education, and it will not be the last. It is crucial to sustain learning through disruptions to ensure education continuity and consistent support for students (Akyıldız, 2020; Daniel, 2020; Miller et al., 2021). As Noddings (2012) highlighted a decade ago, it is still and will be essential to create a climate for caring in addressing students' needs and anticipating and reacting to possible disruptions. For this, the continuance of formal education requires major effort from students, faculty, staff, communities, and professionals (and still others) to cultivate a supportive structure and context for teaching and learning.

We add that the strength of our qualitative approach is that it offers an in depth, meaningful analysis into how students and faculty experienced changes in teaching and learning as the pandemic unfolded. This allowed us to connect obstacles experienced to changes in teaching orientation and the subsequent implementation of specific strategies attuned to these obstacles, which might have been lost in more quantitative leaning data-collection methodologies. Indeed, this insight offers robust insight into instructional strategies that may be leveraged to address teaching and learning disruptions. Specifically, this allowed us to offer insight into the personal, interpersonal, and logistical obstacles faced, how instructors' mindsets changed, and the caring practices used, including an increase in structure, a change in format, and a culture of support.

While our work is most relevant to the STEM service-learning context during pandemic/social disruptions, insights from our research can help universities and their communities be agile in the face of disaster and beyond. Indeed, some of the changes made to adapt to COVID-19 are ones that E-Corps instructors plan to continue to use into the future. Future research investigating both instructional and caring pedagogy in other contexts of disruption (e.g., environmental disaster) could complement this work, helping to craft a more sophisticated modeling of how the type of disaster impacts pivots and pedagogies needed.

Funding: This work was supported by the National Science Foundation under Grant No. 1915100.

Disclosure statement: The authors report there are no competing interests to declare.

References

- Adkins-Jablonsky, S., Fleming, R., Esteban, M., Bucio, D., Morris, J., & Raut, S. (2021). Impacts of a COVID-19 e-service-learning module in a non-major biology course. *Journal of Microbiology & Biology Education*, 22(1), 1-10. <https://doi.org/10.1128/jmbe.v22i1.2489>
- Akyıldız, S. (2020). College students' views on the pandemic distance education: A focus group discussion. *International Journal of Technology in Education and Science*, 4(4), 322-334.
- Arnold, C., Barrett, J., Campbell, T., Chrysochoou, M., & Bompoti, N. (2021). The Environment Corps: Combining classroom instruction, service-learning and extension outreach to create a new model of community engaged scholarship at the University of Connecticut. *Journal of Higher Education Outreach and Engagement*, 25(2), 215-231.
- Arriaza, R., Mutch, C., & Mutch, N. (2021). When Covid-19 is only part of the picture: Caring pedagogy in higher education in Guatemala. *Pastoral Care in Education*, 39(3), 236-249.
- Ayebi-Arthur, K. (2017). E-learning, resilience and change in higher education: Helping a university cope after a natural disaster. *E-Learning and Digital Media*, 14(5), 259-274.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Bozkurt, A., Karakaya, K., Turk, M., Karakaya, Ö., & Castellanos-Reyes, D. (2022). The impact of COVID-19 on education: A meta-narrative review. *TechTrends*, 66(5), 883-896.
- Campbell-Montalvo, R., Campbell, T., Park, B-Y., Arnold, C., Volin, J., Chrysochoou, M., & Diplock, P. (2021). E-Corps' implementation of environmental sustainability-focused service learning: Conditions supporting the establishment of an epistemic community. *Journal of STEM Outreach*, 4(1), 1-12. <https://www.jstemoutreach.org/article/29744-e-corps-implementation-of-environmental-sustainability-focused-service-learning-conditions-supporting-the-establishment-of-an-epistemic-community>
- Christopher, R., de Tantillo, L., & Watson, J. (2020). Academic caring pedagogy, presence, and Communitas in nursing education during the COVID-19 pandemic. *Nursing Outlook*, 68(6) 822-829.
- Collier, D., Fitzpatrick, D., Dell, M., Snideman, S., Marsicano, C., Kelchen, R., & Wells, K. (2022). We want you back: Uncovering the effects on in-person instructional operations in fall 2020. *Research in Higher Education*, 63(5), 741-767.

- Cooke, H., Campbell-Montalvo, R., Campbell, T., Arnold, C., Chrysochoou, M., Park, B-Y., & Diplock, P. (2023). Community-University relationships in environmental service-learning: Social network vectors and modalities of communication. American Society for Engineering Education (ASEE) Annual Conference & Exposition, June 25-28, 2023. Baltimore, MD, USA. <https://nemo.asee.org/public/conferences/327/papers/38359/view>
- Daniel, J. (2020). Education and the Covid-19 pandemic. *Prospects*, 49(1), 91-96.
- Davis, E., Flavin, A., Harris, M. M., Huffman, L., Watson, D., & Weller, K. M. (2021). Addressing student isolation during the pandemic: An inquiry into renewing relationships and reimagining classroom communities on remote instruction platforms. *Journal of Practitioner Research*, 6(1), 2. <https://doi.org/10.5038/2379-9951.6.1.1199>
- DiCarlo, P., Hilton, W., Chauvin, W., Delcarpio, B., Lopez, A., McClugage, G., Letourneau, G., Smith, R., & Hollier, H. (2007). Survival and recovery: Maintaining the educational mission of the Louisiana State University School of Medicine in the aftermath of Hurricane Katrina. *Academic Medicine*, 82(8), 745-756.
- Dohaney, J., de Róiste, M., Salmon, A., & Sutherland, K. (2020). Benefits, barriers, and incentives for improved resilience to disruption in university teaching. *International Journal of Disaster Risk Reduction*, 50, 101691. <https://www.sciencedirect.com/science/article/pii/S2212420920302119>
- Doody, R., Schuetze, P., & Fulcher, K. (2020). Service learning in the time of COVID-19. *Experiential Learning & Teaching in Higher Education*, 3(1), 12-16. <https://nsuworks.nova.edu/elthe/vol3/iss1/8>
- Duffy, R. (2018). *Quality caring in nursing and health systems: Implications for clinicians, educators, and leaders* (3rd ed.). Springer.
- Fishman, B., Penuel, W., Allen, A., Cheng, B., & Sabelli, N. (2013). Design-based implementation research: An emerging model for transforming the relationship of research and practice. *National Society for the Study of Education*, 112(2), 136–156.
- Gin, L. E., Guerrero, F. A., Brownell, S. E., & Cooper, K. M. (2021). COVID-19 and undergraduates with disabilities: Challenges resulting from the rapid transition to online course delivery for students with disabilities in undergraduate STEM at large-enrollment institutions. *CBE—Life Sciences Education*, 20(3), 1-17. <https://doi.org/10.1187/cbe.21-02-0028>

- Gonzalez, A., & Poole, M. (2021). Teachers as instructional designers: Unearthing the essence of the primary school curriculum for delivery within the remote learning classroom. *Journal of Practitioner Research*, 6(1), 5. <https://doi.org/10.5038/2379-9951.6.1.1202>
- Grunspan, D., Holt, E., & Keenan, S. (2021). Instructional communities of practice during COVID-19: Social networks and their implications for resilience. *Journal of microbiology & biology education*, 22(1). <https://journals.asm.org/doi/full/10.1128/jmbe.v22i1.2505>
- Hills, M., & Watson, J. (2011). *Creating a caring science curriculum: An emancipatory pedagogy for nursing* (1st ed.). Springer.
- Irfan, M., Kusumaningrum, B., Yulia, Y., & Widodo, A. (2020). Challenges during the pandemic: Use of e-learning in mathematics learning in higher education. *Infinity Journal*, 9(2), 147-158.
- Krippendorff, H. (2003). *Content analysis: An introduction to its methodology*. Sage Publications.
- Landis, J., & Koch, G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159–174.
- Lederman, D. (2020, April 22). *How teaching changed in the (forced) shift to remote learning*. Inside Higher Ed. <https://www.insidehighered.com/digital-learning/article/2020/04/22/how-professors-changed-their-teaching-springs-shift-remote>
- Lin, L., & Shek, D. (2021). Serving children and adolescents in need during the covid-19 pandemic. *International Journal of Environmental Research and Public Health*, 18(4), 1-16. <https://doi.org/10.3390/ijerph18042114>
- Manier, L., Veague, T., York, T., Wagstaff, I., & Carinci, J. (2022). *Lessons learned during COVID-19: Strategies transforming the future of STEM education*. American Association for the Advancement of Science. <https://aaas-iuse.org/lessons-learned-report>
- Miller, E., Reigh, E., Berland, L., & Krajcik, J. (2021). Supporting equity in virtual science instruction through project-based learning: Opportunities and challenges in the era of COVID-19. *Journal of Science Teacher Education*, 32(6), 642-663.
- Moorhouse, B., & Tiet, M. (2021). Attempting to implement a pedagogy of care during the disruptions to teacher education caused by COVID-19: A collaborative self-study. *Studying Teacher Education*, 17(2), 208-227.

- Mutch, C. (2021). 'Maslow before Bloom': Implementing a caring pedagogy during Covid-19. *Teachers' Work*, 18(2), 69-90.
- Noddings, N. (1995). Teaching themes of care. *The Phi Delta Kappan*, 76(9), 675-679.
- Noddings, N. (2012). The caring relation in teaching. *Oxford Review of Education*, 38(6), 771-781.
- O'Connor, C., & Joffe, H. (2020). Intercoder reliability in qualitative research: debates and practical guidelines. *International Journal of Qualitative Methods*, 19, 1-13.
<https://journals.sagepub.com/doi/pdf/10.1177/1609406919899220>
- Onyema, E., Eucheria, N., Obafemi, F., Sen, S., Atonye, F., Sharma, A., & Alsayed, A. (2020). Impact of Coronavirus pandemic on education. *Journal of Education and Practice*, 11(13), 108-121.
- Oprysko, C. (2020, April 16). *More than a dozen states have extended stay-home orders past White House deadline*. Politico. <https://www.politico.com/news/2020/04/16/coronavirus-stay-home-orders-extended-190889>
- Palmer, L., Pagoto, S., Workman, D., Lewis, K., Rudin, L., De Luna, N., Herrera, V., Brown, N., Bibeau, J., Arcangel, K., & Waring, M. (2021): Health and education concerns about returning to campus and online learning during the COVID-19 pandemic among US undergraduate STEM majors. *Journal of American College Health*.
<https://doi.org/10.1080/07448481.2021.1979009>
- Park, B-Y., Campbell-Montalvo, R., Campbell, T., Hannah, C., Arnold, C., Volin, J., Chrysochoou, M., & Diplock, P. (2022). The development of high leverage practices in environmental sustainability-focused service learning courses: Applications for higher education. *Environmental Education Research*, 28(11), 1635-1655.
- Puccia, E., Martin, J., Smith, C.A.S., Kersaint, G., Campbell-Montalvo, R., Wao, H., Lee, R., Skvoretz, J., & MacDonald, G. (2021). The influence of expressive and instrumental social capital from parents on women and underrepresented minority students' declaration and persistence in engineering majors. *International Journal of STEM Education*, 8(20), 1-15.
- Rajab, K. D. (2018). The effectiveness and potential of E-learning in war zones: An empirical comparison of face-to-face and online education in Saudi Arabia. *Institute of Electrical and Electronics Engineers (IEEE) Access*, 6, 6783-6794.

- Reimers, F. M., & Schleicher, A. (2020). *A framework to guide an education response to the Covid-19 Pandemic of 2020*. OECD. https://oecd.dam-broadcast.com/pm_7379_126_126988-t63lxosohs.pdf
- Rio Poncela, A. M., Romero Gutierrez, L., Bermúdez, D. D., & Estellés, M. (2021). A labour of love? The invisible work of caring teachers during Covid-19. *Pastoral Care in Education*, 1-17. <https://doi.org/10.1080/02643944.2021.1938646>
- Son, C., Hegde, S., Smith, A., Wang, X., & Sasangohar, F. (2020). Effects of COVID-19 on college students' mental health in the United States: Interview survey study. *Journal of Medical Internet Research*, 22(9), e21279. <https://preprints.jmir.org/preprint/21279>
- Soto, N. E. (2005). Caring and relationships: Developing pedagogy of caring. *Villanova Law Review*, 50(4), 859-874.
- Skvoretz, J., Kersaint, G., Campbell-Montalvo, R., Ware, J. D., Smith, C. A. S., Puccia, E., Martin, J. P., Lee, R., MacDonald, G., & Wao, H. (2020). Pursuing an engineering major: social capital of women and underrepresented minorities. *Studies in Higher Education*, 45(3), 592-607.
- Tang, A. L., Walker-Gleaves, C., & Rattray, J. (2021). University students' conceptions and experiences of teacher care amidst online learning. *Teaching in Higher Education*, 1-22. <https://www.tandfonline.com/doi/abs/10.1080/13562517.2021.1989579>
- UNESCO. (2020). *Adverse consequences of school closures*. UNESCO. <https://en.unesco.org/Covid19/educationresponse/consequences>
- Verma, G., Campbell, T., Melville, W., & Park, B-Y. (2020). Science teacher education in the times of the Covid-19 pandemic. *Journal of Science Teacher Education*, 31(5), 483-490.
- Veyvoda, A., & Van Cleave, J. (2020). Re-imagining community-engaged learning. *Perspectives of the ASHA Special Interest Groups*, 5(6), 1542-1551.
- Williamson, B., Eynon, R., & Potter, J. (2020). Pandemic politics, pedagogies and practices: Digital technologies and distance education during the coronavirus emergency. *Learning, Media and Technology*, 45(2), 107-114.
- World Health Organization (WHO) (2020, March 11). *WHO Director-General's opening remarks at the media briefing on Covid-19*. World Health Organization. <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-Covid-19---11-march-2020>

Author Biographies

Dr. Byung-Yeol Park is a postdoctoral research associate in the Department of Curriculum and Instruction at the University of Connecticut. His research focuses on science teachers' curriculum strategies, standards-based curriculum implementation, and students' engagement in modeling activities. He also explores systems thinking based learning, environmental sustainability focused service learning, teacher leadership, and diversity in STEM teaching workforce.

Dr. Rebecca Campbell-Montalvo is a visiting assistant research professor in the Department of Curriculum and Instruction at the University of Connecticut. She is a trained cultural anthropologist whose research focuses on understanding and improving how a range of people (including women, historically excluded racial/ethnic groups, and LGBTQIA+ individuals) are served by institutions, including in undergraduate STEM contexts. Her new book is titled *The Latinization of Indigenous Students* (Lexington, 2023).

Dr. Todd Campbell is the Department Head of Curriculum and Instruction and a Professor of Science Education. He is focused on cultivating imaginative and equitable representations of STEM activity. In formal science learning environments this means collaborating with pre-service and in-service teachers and leaders to interrogate and re-imagine just and thriving futures. In informal learning environments this means focusing on iterative design of informal learning spaces and STEM identity research.

Hannah Cooke is a doctoral student in Curriculum and Instruction at the University of Connecticut. Her research interests include critical, antiracist science education. Her former role as a high school science teacher and facilitator of the school's Green Team led her to grapple with the role science educators play in advancing environmental and racial justice.

Oxana Sidorova is a master's graduate of El Instituto at the University of Connecticut. Her thesis focuses on the identity and language education of the indigenous community Koreguaje. She is currently a doctoral student at the University of South Florida in the Department of World Languages. Her research focuses on migrant workers' identity construction in narratives about their language experiences.

Chester Arnold is an Extension Educator Emeritus at the University of Connecticut. He is the co-founder and former Director of the Center for Land Use Education and Research (CLEAR). Chet's areas of interest and research include stormwater management, watershed management, STEM education, and land use change and its impacts on natural systems.

Dr. Marisa Chrysochoou is a Professor and Head of the Department of Civil and Environmental Engineering at the University of Connecticut. Dr. Chrysochoou's general research area is environmental geochemistry, with a focus on site remediation and redevelopment, characterization and reuse of industrial waste and construction materials. Dr. Chrysochoou serves as the Director of the EPA Region 1 Technical Assistance for Brownfields (TAB) Program.

Dr. Peter Diplock is the Associate Vice-Provost for the University of Connecticut's Center for Excellence in Teaching and Learning (CETL), a role he has occupied since 2012. Peter provides thought leadership for developing new and innovative academic programs and elevating teaching and learning outcomes. He earned his Bachelor's degree in Economics from the University of Western Ontario, and his M.B.A. and Ph.D. in Management from the University of Massachusetts.

Appendix A

Developed Codes for Data Analysis

Constructs	Codes	Theme	
Perceptions on E-Corp Class	1.0	General or overall thoughts	
	1.1	Challenges in course (and what contributed to them)	
	1.2	Successes in course (and what contributed to them)	
	1.3	Things people liked (use more for students)	
	1.4	Things people disliked (use more for students)	
	1.5	Interactions with guest speakers/community members (townspeople) (indepth) or applied	
	1.6	Student group work (indepth)/how it actually went	
	1.7	Proposals/projects/reports/outcome	
HLPs	2.0	Understandings/Feedback on HLP document	
	2.1	How these were or were not implemented or the instructor wants to implement them in the classroom	
Institutional	3.1	Institutional concerns, funding, support that faculty have	
	3.2	Spreading model to other campuses	
Other	4	4.1	Other important/interesting things to note
COVID-19	5.1	Obstacle to teaching and learning: Personal (i.e., home distractions caused by interactions with others in the household, COVID-19 related physical health concerns, mental health issues, etc.)	
	5.2	Obstacle to teaching and learning: Technical (i.e., problems accessing specialized software due to campus closure, internet connectivity issues, difficulty learning online, etc.)	
	5.3	Obstacle to teaching and learning: State's closure of public buildings (i.e., inability to visit public buildings to access maps and information, inability to visit research sites, etc.)	
	5.4	Success/Pedagogies: Successes in continuing these courses online/things instructors or students did to deal with it (good attendance online, continued municipal/industry involvement, instructor pedagogical practices that addressed negative impact of the obstacles, etc.)	