SCIENCE EDUCATION & CIVIC ENGAGEMENT

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*Deceased

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Contents

About the Journal

Science Education and Civic Engagement: An International Journal is an online, peer-reviewed journal. It publishes articles that examine how to use important civic issues as a context to engage students, stimulate their interest, and promote their success in mathematics and science. By exploring civic questions, we seek to empower students to become active participants in their learning, as well as engaged members of their communities. The journal publishes the following types of articles:

- ***Book & Media Reports***
- ***Point of View***
- ***Project Reports***
- ***Research***
- ***Review***
- ***Science Education & Public Policy***
- ***Teaching & Learning***

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WWW.SECEIJ.NET

From the Editors

For the Summer 2020 issue of this journal, we are very excited to highlight a special section on *Teaching Through COVID*. These reflections document experiences and lessons learned while teaching science and civic engagement during the COVID-19 pandemic. We received a very enthusiastic response to our call for submissions, and we are publishing 35 contributions to this special section.

This issue also features two project reports and one research project that cover a range of interesting educational strategies to teach STEM through a civic framework.

Jo Hardin (Pomona College), together with **Karl Haushalter** and **Darryl Young** (Harvey Mudd College), describe their participation in the Inside-Outside Prison Exchange Program that creates a shared community of campus-based college students and incarcerated students who take a college course taught in a correctional facility. Because STEM is often lacking in the prison curriculum, the authors taught courses in statistics, number theory, and biochemistry. This article provides a reflection on the unique opportunities of teaching STEM within a prison education program.

Based at the NYC College of Technology, City University of New York, **Melanie E. Villatoro** and **Janet Liou-Mark** established a National Summer Transportation Institute to recruit a diverse population of high school students with an interest in careers in transportation. The program provides a creative model for broadening participation in STEM and encouraging students to pursue STEM careers.

Sara Haines and **Chelsea McClure**, both at Towson University, developed a partnership with the National Aquarium in Baltimore to implement a civic engagement model for the professional preparation of preservice and K-12 teachers. This program provides a valuable example of a place-based curriculum that engages environment awareness by examining issues of direct importance to the local community around the Chesapeake Bay

We wish to thank all the authors for sharing their articles with the readers of this journal.

Matt Fisher
Trace Jordan
Co-Editors-in-Chief

SPECIAL SECTION

FROM THE EDITORS

Teaching through COVID-19

IT FEELS LIKE AGES AGO that the World Health Organization announced that it had identified a novel coronavirus virus that causes COVID-19. But that was just eight months in the past, during the first weeks of January 2020. So much has happened since then, and so much remains uncertain. By the middle of March, almost all colleges and universities had announced that they would be moving to entirely online classes for the rest of the spring semester, an unexpected transition never before experienced by higher education.

All of a sudden, rather than just connecting science and civic engagement in our classrooms, we were living it. STEM faculty were forced to make significant modifications to their courses with little time to plan for the transition. The reflections that follow are a first attempt to capture the range of what faculty tried, what worked, and what didn't. It has been said that journalism is the first draft of history. We hope that what we have assembled here is a first draft of what it meant to teach through COVID-19 in the spring 2020 semester.

These are not formal research papers or project reports like those found in past issues of SECEIJ. Instead, we invited interested faculty to submit reflections of no more than 1,500 words-and all submissions were reviewed by the co-editors in-chief,. Some authors chose to include some references in their submission while others took a more personal approach.

These submissions presented us with a broad range of faculty creativity, thoughtfulness, and reflection. We hope you find reading them as thought-provoking and informative as we did.

Matt Fisher
Trace Jordan
Co-Editors-in-Chief

Contents

Contents

A Reflection on Teaching During a Pandemic – Outbreak!

Joanne Bartsch
Carolina Day School
Asheville, NC

This piece doesn't actually directly address the topic of teaching through COVID-19; I believe however, that my experience and that of my students as we face this pandemic has been deeply affected by my experiences with SENCER.

Carolina Day School, an independent PK-12 school in Asheville, North Carolina, has been represented at five of the last six SENCER Summer Institutes, and our Upper School faculty currently boasts seven SSI alumni. SENCER ideals have been incorporated not only into our science curriculum, but also into that of math, fine arts, social sciences, and English. But one of the most successful results of our involvement with SSI is Outbreak!, a unit taught to high school freshpersons. Outbreak! was developed, refined and implemented by SSI alumnae Joanne Bartsch, Prudence Munkittrick, and Nina LaFerla, based on our work at the Worcester Polytech and Roosevelt University SSI gatherings.

Outbreak! is simultaneously taught to ninth-graders in their Global Studies and Human Biology courses. Our foundational idea for the unit is that the spread of a disease is the result of interactions between its agent, the host, and the environment—the epidemiological triangle. We want students to see how these factors all contribute to epidemics and to recognize that protecting human health requires an understanding of all parts of the triangle.

Through labs, small group work, class discussions, and long-term projects in their Human Biology class, students learn about the characteristics of and relationships between host and agent. We cover the structure, life cycles, and virulence factors of agents as well as immune response and medical response (therapeutics and vaccinations) on the part of the host. In Global Studies, students come to understand infectious diseases from the perspective of host and environment—demographics, geography, political structures, and socioeconomic factors. Again, through class discussion, projects, and group collaboration, they analyze causes of and responses to historical outbreaks of disease, from cholera to Spanish flu to yellow fever to AIDS. In the culmination of the unit, groups of students are presented with an imaginary outbreak of a real disease (MERS, polio, typhoid) in a location facing some kind of real crisis (Aleppo, Caracas, Guatemala City, Nairobi). The students are tasked with developing a response to this imaginary outbreak using accurate and current knowledge of the agent, the host, and the environment. Our students have navigated earthquakes, floods, civil wars, dictators, poverty, and privilege as they have imagined how to most effectively break the triangle in their given scenario.

We were one week away from implementing our fifth year of Outbreak! when I found myself in front of the student body as we hurriedly made preparations to transition to remote learning. It was my job to explain the necessity of social distancing from an epidemiological perspective. Since 75% of the students in the room had completed the Outbreak! unit, that's where I began. Of course, I reminded them of how they had learned the necessity of breaking the epidemiological triangle; that reminder could come from any course or any teacher. But because Outbreak! did not ask them to rely just on science to solve a problem, and because it allowed them to wrestle with a complex, capacious problem so similar to the one they were about to face in real life, the lessons they learned from it were, I think, far more useful to them than a recitation of basic facts. I reminded them that many of the responses we were seeing in real time were exactly the ideas they had developed on their own—mobile clinics, handwashing stations, educational campaigns, fundraising, resource mobilization, research, activism, and vaccination development. (In a bit of premonition, some of our students envisioned the importance of face masks and even developed personalization for them in order to enhance their use.) I asked them to pay attention to all of these responses in the news over the next few months. Never before has the question "When am I ever going to use this?" had so clear and valuable an answer.

While their response plan was in fact their final assessment, we finished the unit by playing the board game Pandemic, and I reminded them of the lesson from that as well—that any response to a pandemic like this one requires a full community commitment and collaboration among many partners.

I have no SENCER-SALG on what happened in that moment, nor do I have one for what is happening now as our students deal with this pandemic and see its effects first hand. Anecdotes are not evidence, but I am convinced that the SENCER-inspired Outbreak! unit—and its relevance in this moment—demonstrate the value of implementing SENCER ideals in all classrooms.

Because of the difficulties of changing the interdisciplinary unit to remote learning, it was not taught in Spring 2020. I used parts of my side of it to help students understand the problems of COVID through the lens of biology and science. Even remotely, they continued to try to solve complex and capacious problems as they used their knowledge of the virus's life cycle to imagine and "design" a therapeutic to treat the disease. And for next year's freshpersons, Outbreak! will be updated to reflect what we have learned from this most recent "grand challenge."

Interdisciplinary and Community Collaboration through the Transition to Distance Learning caused by the COVID-19 Pandemic

Diane C. Bates, Jessica King, Kim Pearson, and S. Monisha Pulimood
The College of New Jersey
Ewing, NJ

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https://www.nsf.gov/awardsearch/showAward?AWD_ID=1914869

We would like to share our experiences working with the Collaborating Across Boundaries (CAB) team during the Spring 2020 transition to remote learning. The CAB team consisted of three sets of professors, whose classes were paired across science and non-science disciplines to work on a STEM-related community-engaged project. These collaborations included: (1) business and computer science courses, who worked with an environmental policy non-profit on a variety of projects, most of them focused on environmental issues like reducing the carbon footprint and recycling; (2) computer science and journalism courses, who worked with a non-profit news provider to improve content delivery on their website; and (3) environmental sociology and women's and gender studies courses, who worked with a fifth-grade Girl Scout troop on projects related to sustainable energy. The following observations are derived from journals kept by the six participating professors, transcribed discussions among faculty participants, and the transcript of a focus group led by an outside evaluator. We limit our findings to three observations about the transition to online learning that are unique given our collaboration between students in different classes and a community partner. We found: (1) a small but important number of students struggled with online participation; (2) communication among students was similar to or more problematic than we have seen previously; and (3) community-engaged projects suffered because community partners were also rapidly transitioning to new procedures related to the pandemic.

A small but substantial number of students were unable to consistently participate in classes, even asynchronously, due to illness, illness in the family, technical difficulties, and/or a variety of other problems. Because our college serves a population that draws predominantly from one of the early pandemic hotspots in the United States, this was likely a greater issue here than in other parts of the country. One professor noted, "I had a number of students lose grandparents, take on additional responsibilities around the house, [or who] have just disappeared, so [the project] has sort of taken a back seat." Another explained, "At least one student, possibly two, contracted COVID-19, along with other family members. Another student found herself responsible for the care of both her mother and brother. Another student said there was no space at home to do schoolwork. Another had internet connection problems. Two students had no audio on their computers. Mental health issues became a consideration." Professors noted that students were reluctant to explain their situation to them or other students. Three common problems involve taking up care responsibilities for younger siblings or ill family members, sharing computers or physical spaces, and a variety of technological problems. Our students also juggled new work responsibilities, such as one student who was "required" to work additional hours at an essential business because he did not have dependent children. Students who struggled to participate affected the ability of other students to do the work; one professor explained, for example, "Two of the students couldn't get in touch with two other students in my class who were supposed to be working with them on this project, and so they ended up doing the bulk of the work. Then it turns out that one … almost checked out, was doing that because of personal reasons, and … they didn't know the other students, didn't tell them about it." Professors generally responded with flexibility around deadlines, but our experience suggests that more systematic processes for students in these situations would be beneficial.

Students struggled with communicating with one another even more than usual, but this was mitigated by having previously established communications through a shared learning management system (LMS). There was considerable variation here. One professor noted what may be "reticence" or at least "unevenness" among students for taking responsibility to contact classmates outside of class, "and when you add to that students that they're not seeing on a regular basis, I think it gets a little bit more complicated." Alternately, another professor found little difference before and after the transition: "Some groups continue to report that the collaboration was a complete failure and say their… teammates ignore all their attempts at communication; other groups continue to report better experiences." Students used many ways of communicating with their peers, but they clearly benefited from using an LMS that was monitored by professors. One professor explained, "I'm not sure that I would have the stomach for another collaborative measure without the combined [LMS] tool. Almost nothing we've done, created, and inspired could have been done without this shared platform without it requiring tremendous hurdles and encumbrances. And this is just amazing, the groups just post their stuff, they put it on the discussion board, other groups can comment on it, regardless of class; … it breaks all those barriers down in a way that signals that this is a project that's about working together." We thus emphasize the advantages of using an LMS for collaboration while remote learning.

Working with community partners created additional coordination problems. Community organizations were also facing shut-down pressures, and many understandably prioritized their own concerns before responding to students. One professor lamented roughly two weeks into remote learning: "Our community partner has not responded to emails, so we don't know what's going on there." Another explained that the community organization with which they were collaborating "was not even able to distribute the material for procedures involving [remote] meetings until the end of April, … which meant that we couldn't even meet with them on [-line] during most of the time when our students should have been collaborating with them." A third professor explained, "In order for my students to execute their projects, they not only have to interact with community partners, they had to interview sources, other sources, [contact] government offices and others, so because of the pandemic, those sources often weren't available or didn't respond in a timely fashion." All three collaborations had to be modified in order to conclude before the semester ended, in large part because of interruptions linked to working with community organizations. This experience suggests that indirect service projects, where students work with guidance from a community partner's staff, were more amenable to the transition to remote learning than were direct service projects, where students interact directly and continuously with members of the community. Although direct service could in theory still occur, we found that it was not feasible given the time constraints of the Spring 2020 semester and the emerging situation of community organizations.

Teaching Emerging Diseases During an Emerging Disease Pandemic

Rachel A. Bergstrom
Beloit College
Beloit WI

Emerging Diseases (BIOL 215) supports student learning of complex microbiology and epidemiology concepts by using case studies and examples of outbreaks in the news (Ebola, influenza, and measles), including materials published in the SENCER model course (Bergstrom and Fass, 20) and accounts of historical events (AIDS and many outbreaks chronicled by Laurie Garrett in *The Coming Plague* [2020]). The immune response, vaccine biology, herd immunity, and viral replication and mutation seem less abstract when students see the context of the concept in an outbreak. Students frequently comment on this connection in course evaluations and note how it positively impacts their learning.

COVID-19 was a fascinating and relevant addition to Emerging Diseases this spring. But because there wasn't much known about the virus or the disease, and because we had other viral diseases that we could learn from as we followed the outbreak, we didn't spend much class time early in the semester focused on the novel coronavirus. As we learned about virus-host interactions through Ebola, influenza, and measles, we added knowledge on host specificity, spillover, and how population density affects the spread of a new viral disease. At the same time, we watched the pandemic unfold, learning why epidemiologists track outbreaks in terms of person, place, and time. We tracked the spread of COVID-19 through China (and then around the world) on the Johns Hopkins dashboard (CSSE at JHU, 2020), and explored how a change in the case definition led to a one-day spike of 15,000 new cases in China on February 13.

In late February, my approach to COVID in class changed. We were no longer watching the outbreak from afar. We shifted from a distanced, academic fascination with understanding the biology of COVID and the impact of human behavior on COVID to experiencing the outbreak. Students wanted to know whether or not they should travel over spring break. And students were taking on the role of disease expert for their families and friends. They wanted to know more. When we shifted to distance learning after spring break, it felt impossible to do anything but lean into the pandemic to provide some context for what we were all experiencing.

I structured the online portion of the class as a combination of synchronous and asynchronous content, as I had students all over the world and with many different responsibilities now that they had moved home. I posted background readings and instructional videos to our online learning management system (Moodle). I wanted to maintain some normal course structure, so we met during our regular class time, which I also recorded and posted to Moodle. These classes began with a pandemic update. I used narratives in the news to choose topics: vaccine trials to explore the FDA approval process; challenges and successes in COVID-19 testing to learn about PCR, rtPCR, ELISA, and antibody testing. We compared flattening the curve through social distancing to herd immunity and analyzed the White House's plan to relax social distancing restrictions.

I let student interest and inquiry guide our discussions, such as when students described with amazement that simple things like trips to the grocery store were now exciting. This evolved into a discussion of how people respond to an outbreak, from how my students thought we should all respond (in particular, wearing face coverings and maintaining social distancing measures when out in public) to how they were seeing friends, family, and strangers respond differently (ignoring guidelines for disease prevention and looking to conspiracy theories to explain our current realities). Here is where I noted the biggest shift in how students engaged with the course.

When the outbreak is "over there," whether Brooklyn (measles), Sub-Saharan Africa (AIDS), China

(COVID-19), or West Africa (Ebola), building empathy for the fear and anxiety of the people experiencing the pandemic is mostly an academic exercise. Students understand that they should feel empathy, but it is often hard to internalize how that empathy can influence their understanding of the underlying human contribution to disease. In a normal year, we discuss cultural responses to and explanations of disease, but empathy and understanding for how some people respond to disease, including anti-vaccine and religious groups, and how we can responsibly work with (and not over or against) these groups is difficult to build. But this year students noted that they were, themselves, feeling the fear and uncertainty of living in an outbreak, as well as the boredom and anxiety of living under quarantine. They observed that they hadn't before thought about how these feelings could easily lead them, in the absence of their knowledge about emerging diseases, to seek out alternative explanations for the disease and our response. They started to think about how they could even resist the guidelines meant to protect us. Students were fully experiencing and understanding that the human response to a disease outbreak is shaped by experiences, knowledge, and cultural influences far beyond basic microbiology and epidemiology.

Teaching Emerging Diseases during an emerging disease pandemic was at the same time simple and challenging. Of course, the context and immediacy of the pandemic boosted student motivation for learning biological concepts. The physical distance of Zoom coupled with my own feelings of anxiety and exhaustion for the all-COVID-all-the-time nature of living in a pandemic wore on me and my students. In course evaluations, some students noted that they liked having a place to come twice a week for a reality check on the pandemic. And some students lamented that they felt like they missed out on other important disease models because we spent so much time on COVID. I think this means we hit a good balance. In years to come, I'll be incorporating COVID into my regular schedule of diseases. As a universal experience for students, the power of COVID is that we can honor our shared understanding that outbreaks are powerfully shaped and influenced by human behavior and experience.

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Encouraging Informal Learning in STEM Through the COVID-19 Era

Natalie Brown, Sean Stevenson, and Stuart Thorn
University of Tasmania
Hobart TAS, Australia

The Peter Underwood Centre is a partnership between the University of Tasmania and the State Government with a mission to increase the educational attainment of young people in the state of Tasmania, Australia. A key focus of our work is to encourage informal learning that is child-led, engaging, and connected to opportunities both at the University and in the community. The Centre facilitates the Children's University program (Shelley, Ooi, & Brown, 2019), where participants (aged 7–14) engage in validated extracurricular activities and collect hours of learning to be eligible to graduate in an annual ceremony. A second initiative is our A-Lab, a technology-equipped learning space that facilitates engaging experiences, with a STEM emphasis. These are delivered *in situ*, in school or in community settings. Early in 2020, there was a planned expansion into an interactive STEM gallery in the heart of the city. This collaboration with researchers, community, and educators, aimed to bring the research of the University to young people, teachers, and the community in innovative ways. Our chosen focus on STEM recognised its engaging and hands-on nature, the strengths of the University faculty, and the promise of STEM to contribute positively to Tasmanians and the economy of the state.

The COVID-19 restrictions brought the STEM gallery project to an abrupt halt in March 2020. Staying at home, and learning at home, also affected activities that were supported and promoted through Children's University. The potential loss of momentum of these two projects came at a time when, more than ever, families were seeking ways to keep children and young people engaged and interested in learning. Our challenge was to continue to support Children's University as well as maintain the momentum of the collaborative effort and optimism of the STEM gallery project. A complication was that many Tasmanian families face challenges with digital inclusion. Our solution was to develop two new, child-focussed media products.

The Wonder Weekly is a full colour, child-friendly newssheet with stories, puzzles, activities, and challenges that can be completed at home without the need for a computer (see for example https://www.utas.edu.au/__data/assets/pdf_file/0003/1337601/The-Wonder-Weekly-June-8.pdf). With support from a national supermarket chain, *The Wonder Weekly* is printed and distributed free of charge throughout the state, as well as being available online and through Tasmanian schools.

During a situation such as the COVID-19 pandemic, the media are inundated with information, opinions, and data that can become overwhelming, especially to young people. There is evidence that constant updates can cause elevated anxiety, and professionals advise limiting the amount of exposure to excessive or confusing media (Blackdog Institute, 2020). Consequently, we made a conscious decision not to focus articles on the virus, but to build important scientific literacy skills using other engaging content that would connect with Tasmanian children.

Inspiring a sense of wonder and curiosity that drives inquiry is at the heart of developing scientific literacy in children. It can be the basis for an introduction to the language of science, causal explanations that draw on scientific theories, and the systematic processes that scientists use to collect, analyse, and interpret observations and data (see for example Callanan & Jipson, 2008).

The editorial content of *The Wonder Weekly* has encompassed issues of biodiversity, biosecurity, and sustainability presented as stories that connect to children and introduce scientific language as well as research undertaken by scientists. Meeting the dog used to detect invasive species on Macquarie Island and hearing about conservation of the endangered red handfish are two examples. Stories have also reinterpreted scholarly work of University scientists in ways that are accessible to young people. Two examples are learning about active volcanoes on Australian offshore islands and examining what research into emu poo can tell us about habitat change. Challenges have ranged from the citizen science of bird identification, creating maps and plans, and building and testing structures using principles of engineering design.

A weekly free Zoom broadcast, *UCTV Alive for Kids,* was also launched, drawing initially from the scientists contributing to the STEM gallery project. Short multimedia presentations are followed by interactive sessions, where participating children can use the chat function to send questions to the presenters, mediated by a host. Directly connecting researchers to children and families provides outreach that sparks further interest, and, importantly, makes the science accessible and relevant.

The *UCTV* content has been designed to complement *The Wonder Weekly,* with presentations from vulcanologists, engineers, and aquaculturists. The theme of sustainability was addressed through a multimedia presentation from a scientist who carries out an annual survey of plastic waste on a remote part of the Tasmanian coastline. The questions raised affirm that children have an inherent curiousity and are motivated to act upon this in positive ways. Questions following the plastics session included this one: What actions could individual children take in their homes, schools, and communities to reduce plastic and microplastic waste?

The COVID-19 situation has had a significant effect across the world on children and their families (Brown, Te Riele, Shelley, & Woodroffe, 2020). It has also provided opportunities to reach out in new and different ways. *UCTV* and *The Wonder Weekly* have provided platforms to connect university scientists with children in a format that is engaging and more sustainable than other methods of outreach. Material for both publication and presentation is easy to describe, has a defined purpose and boundaries, is cost effective, and is less time consuming than engagement modes. It also allows for a greater number of scientists (including young research students) to communicate their work to the community.

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How COVID-19 Uncertainties Became a Topic of My Class on Uncertainty

Jackie L. Collier
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, NY

During the Spring 2020 semester I was teaching a section of SBU102, a freshman seminar course intended to help students connect with faculty in a more personal way than their other courses—often large, introductory-level lecture format—make possible. This was only my second time running the course, and the topic was the same as the first: Uncertainty.

The perception of uncertainty is a critical component of how the public interprets the reliability and implications of new scientific information. Clearly presenting uncertainty is also a particularly challenging task in communicating science, at least partly because scientists develop specialized habits and shorthands of thinking and talking about sources and impacts of uncertainty in their own field of study, while the general public, decision-makers, and even scientists from other fields, are likely to come to the conversation with different language. Nonscientists may perceive scientific statements of uncertainty meant to describe how well we know something as indicating instead that the results can't be used to make decisions, or may perceive the change of results over time as an indication of bad science rather than the normal process of refining knowledge. We need to develop a common language by which to convey whether uncertainty in scientific results reflects measurement error (the limited precision and/or accuracy of a method), indeterminacy (the limited ability to know all relevant parameters in a complex system), or ignorance (things we don't even know that we don't know).

My long-term goal is to contribute to bridging this communication gap. As a first step, I'm learning to teach about the topic in SBU102. The course description reads: "Uncertainty is a fact of life. On matters small and large, we make individual and societal decisions in the face of diverse sources of uncertainty. Sometimes we explicitly acknowledge uncertainties, but often not. .... In this course we will think explicitly about uncertainty, and whether/how communicating more clearly about uncertainty can help decision-making in many contexts, with a focus on public policy decisions with a substantial scientific component" (https://you.stonybrook.edu/scientificuncertainty/sch-102-uncertainty/). My goals are that students will learn (1) to identify and describe different sources of uncertainty and (2) to apply that understanding to personal and public policy decision-making. This Spring, I incorporated an introduction to a structured form of decision analysis which integrates uncertainty by using Bayesian approaches to combine the probabilities of different outcomes with separate consideration of the utility (desirability) of each outcome, thereby identifying the choice most likely to lead to the best outcome.

I used a start-of-semester survey to gain insight into the students' backgrounds, interests, and motivations for choosing my section of SBU102. The class attracts students from diverse majors, from arts through engineering, bringing many perspectives to broad class discussions. Although I assure them that "because it fit my schedule best" is a perfectly valid reason for choosing SBU102: Uncertainty, most students say they signed up because of genuine interest in the topic. Sometimes this interest is academic, but more often it is prompted by a desire to find better ways to make personal decisions in the face of uncertainty.

The main assignment for the semester, based on which students both gave a presentation and wrote a final essay, was to find an example of uncertainty affecting a public policy decision, do background research to identify at least two policy alternatives and their implications, and use the Bayesian framework for decision analysis to determine which option would have the best chance of producing the most desirable outcome. I gave the students great leeway in choosing an issue that fit their interests: topics this semester ranged from how to regulate "loot boxes" in video games, to rightsizing public investment in exploring space vs. the oceans, to gun control policy, to reducing discrimination based on skin tone in India.

The outbreak of COVID-19 had, of course, practical impacts on the class, forcing us to move our last several meetings (which included almost all of the students' presentations) onto Zoom. But, because we were lucky to have the practical parts work out rather smoothly, the intellectual impact was greater. Of 15 students, four changed their initial topic and focused their project instead on some aspect of COVID-19 response: Was SUNY right to close campuses at spring break rather than finishing the semester in person? Is it better to buy groceries in person or online? Should wearing face masks be mandatory or optional? Could there be positive environmental outcomes from COVID-19 if, rather than returning to business as usual, online attendance at meetings remained a real option? The Bayesian decision analysis led these students to conclude, respectively: yes, online, optional, and yes.

The end-of-semester class survey showed that most students expected the decision analysis framework they practiced in this class would be generally useful in their personal and academic lives. Although most of them did not want to do the actual math, simply having this structured approach in their toolkit helped them feel better able to manage uncertainties in their decision-making. I expect the pandemic to continue offering them opportunities to practice.

Perhaps this way of explicitly accounting for uncertainty can also form the basis for improving communication about uncertainty in science. That will be my focus for next Spring, if the uncertainties resolve in favor of another year for SBU102: Uncertainty.

COVID-19 Response: A Bonus Assignment for Organic Chemistry Students

Shawn Hitchcock
Illinois State University
Normal, IL

Sibrina Collins
Lawrence Technological University
Southfield, MI

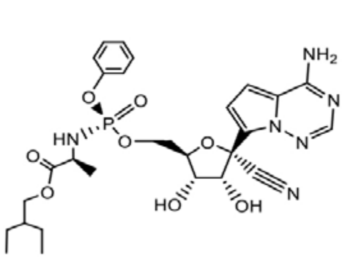
Abstract

The global pandemic caused by the coronavirus (COVID-19) is illustrating in real time why the field of chemistry is so important in developing a vaccine to stop the spread of COVID-19. The race to find a cure for COVID-19 has led researchers to evaluate various potential treatments such as the antiviral drug Remdesivir, which was developed previously to treat Ebola. This chemistry exercise focuses on students' applying chemistry concepts to the Remdesivir molecule. Students enrolled in an organic chemistry survey course were given a bonus assignment to evaluate the antiviral drug. Effective engagement provides students with the opportunity to see the importance of what they are learning in the classroom.

Keywords: Organic Chemistry, Stereochemistry, Student-Centered Learning, Drugs/Pharmaceuticals, Inquiry-Based/Discovery Learning, Communication/Writing, Second-Year Undergrad

Remdesivir (Figure 1) is an antiviral drug that was previously developed to treat Ebola but is now being evaluated as a potential treatment for patients diagnosed with the coronavirus (COVID-19) (Jarvis, 2020). Currently, there are over 15.5 million confirmed global cases of COVID-19, with over 4.2 million cases confirmed in the United States (CDC, 2020). We have utilized the Remdesivir drug to develop a bonus problem set for an organic chemistry survey course (CHE 220-A) with 26 students at Illinois State University (Normal, IL). The students are primarily from diverse majors including nutrition and dietetics, agriculture, and environmental health and safety.

FIGURE 1. Remdesivir



The bonus problem set focused on the Remdesivir molecule included the following questions:

1. Examine the chemical structure of Remdesivir provided. Identify the total number of chiral centers in this molecule.
2. Identify the functional groups present.
3. There is an amino acid fragment in this molecule. What is the name of the amino acid?
4. Identify the most polar region in this molecule.
1. Identify the furan ring in this system.

Independent of the phosphorus chiral center, the students were asked to determine the number of chiral centers and then calculate the number of potential stereoisomers. The correct answer for the Remdesivir molecule is 5 stereocenters, and consequently 25 = 32 stereoisomers. Approximately, 35% (N = 9) of the students answered both questions correctly, while 38% (N = 10) did not determine the correct number of stereocenters, but did properly calculate the number of stereoisomers. Two students (8%) correctly determined the number of stereocenters, but did not properly calculate the number of potential stereoisomers. Five students (19%) did not answer either question correctly.

The students enrolled in the organic chemistry survey course provided very positive and thoughtful feedback on the bonus assignment:

"My opinion on the bonus assignment was that it was a really interesting assignment. I like how we are able to relate current situations to what we're doing in class (although unfortunate that we're going through this type of situation)."

"I personally enjoyed the assignment, I didn't feel as though it was too difficult to complete, and I enjoyed completing something that was connected to the pandemic we are all living through currently. I think the topic made doing the assignment much more interesting."

"I thought this assignment was a good one, because this is something we are all living through and learning more about its organic chemistry was interesting and educational for the sole fact that most of us, the younger generation isn't taking it as serious as it should. I thought it was a cool assignment, thank you!"

In addition, the crystal structure of Remdesivir Dichloromethane Solvate Monohydrate is found in the Cambridge Structural Database (Siegel et al, 2017). Thus, organic chemistry students could also visually examine the structure of Remdesivir to help them identify the chiral centers within the molecule. (Inorganic chemistry students could identify the potential metal binding sites within the structure.)

Although the bonus chemistry assignment did not target general chemistry students, the Remdesivir molecule can be used to focus on concepts such as mass percent composition and VSPER (Valence Shell Electron Pair Repulsion) Theory for the general chemistry demographic. The first-year students could answer the following questions:

The antiviral drug Remdesivir has the following molecular formula C27H35N6O8P with a molar mass of 602.6 g/mole.

1. Calculate the mass percent of carbon (C) in Remdesivir.
2. Calculate the mass percent of oxygen (O) in Remdesivir.
3. Using your knowledge of VSEPR Theory, predict the geometry around the central phosphorus (P) atom in Remdesivir.
4. Would you expect Remdesivir to be polar or non-polar? Would you expect Remdesivir to exhibit dipole-dipole forces? Why?

Furthermore, chemistry faculty could also develop questions based on the dosage of Remdesivir for treating patients diagnosed with COVID-19, such as the following: If the proper dosage of Remdesivir is XX mmol/kg body weight, how many mg would a 65 kg person require? (There is limited data available, but a single dosage of 200 mg has been reported for Remdesivir.) This type of question emphasizes the importance of stoichiometry and concentrations of solutions.

Although the bonus chemistry assignment focused on the antiviral Remdesivir, it can certainly be applied to other potential treatments for COVID-19. At this time, Remdesivir is not a cure for COVID-19 (Cortez, Kresge, & Sink, 2020). The global pandemic caused by the novel coronavirus has illustrated in real time the importance of chemistry to solve ongoing challenges in society. Furthermore, the race to develop new treatments for COVID-19 provides students with the opportunity to see that the concepts they are learning in the classroom are critically important. Making key connections between chemistry concepts in the classroom and real challenges facing our society remains an important strategy for educators as we work to engage the next generation of chemists.

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Teaching First-Year Composition Through COVID-19

Theresa Conefrey
School of Engineering
Santa Clara University, Santa Clara, CA

While teaching my first-year composition course during the ongoing COVID pandemic was challenging, it offered a unique opportunity to teach SENCER ideals that often seem very abstract to students. How to feed a rapidly increasing population while sustaining the health of the planet was the topic that I had planned for my science-and-society-themed course. I intended to focus on the 2019 report by the EAT-Lancet Commission, a group of international scientists, who came together to solve the intertwined issues of climate change and world hunger.

These scientists proposed the plant-based "Planetary Diet" as the best compromise to relieve food insecurity and simultaneously reduce climate change. Like me, students appreciated the symmetry and simplicity of a diet that could promote both our health and that of our planet. However, they argued that no matter how beneficial this way of eating might be, it would never be adopted, because most people would not be willing to accept such a drastic reduction in their meat consumption. "If most Americans won't go for 'Meatless Mondays,' they claimed, "how will they ever agree to a plant-based diet?" Others added that even if Americans would agree to change their eating habits, it would not solve the problem, because international cooperation would be required for global change.

Once I started teaching through the COVID pandemic, I began to see the potential for some valuable comparisons between these interconnected, global issues. I asked my students to consider all the recent changes to our lives that we have accepted during the pandemic. We have seen college courses move online, people staying home, and restaurants, malls, and other non-essential services closing. Not only that, but conducive legislation at all levels was quickly put in place, and cooperation and collaboration were achieved; many people changed their behaviors and followed lockdown restrictions more for the benefit of vulnerable others than for themselves. Before the pandemic was declared, few might have expected that China, South Korea, and European countries, initially hit hard and hit early by COVID, would have been so willing to share their research findings and tracing expertise with the rest of the world. And, in terms of global cooperation, we have witnessed a significant amount of collaboration around developing a vaccine, suggesting that the sharing and cooperation that we would have deemed impracticable are indeed feasible.

Some students, for whom the devastating forest fires in Australia were only a distant memory, objected that COVID and sustainability are not comparable because the former is urgent and tangible, whereas climate change is viewed as less immediate and abstract. However, what is undeniable to our students is the old adage, "Where there is a will, there is a way!" When a situation is understood as sufficiently serious, individuals and societies are able to bring about changes that earlier might have seemed too expensive, too complicated, too controversial, and too inconvenient. And, we have seen how these changes have been supported at the international, governmental, institutional, and local level by funding, legislation, and widespread support from the public.

Another teachable moment for my students has been the very public nature of science unfolding in the media. Suddenly science is of interest to everyone, and we are glued to our screens following the latest theories on how and where COVID-19 originated, its incubation period, how to treat it, and how to protect our communities. Students have watched how science-based recommendations have evolved and changed and how some aspects are still highly contentious, such as treatment protocols and face coverings. They have witnessed how some people have become impatient with the scientific method because of its plodding pace and inherent fallibility, and have sought immediate and definitive answers from fake news sources that seemed more certain and unwavering in their claims. Where posts lacking credibility have gone viral and propagated dangerous advice, students have realized that not all facts are equal and that polished and persuasive appeals are not always trustworthy and reliable. Now that we have seen that fake news can kill, it has become easier for me to stress the importance of investigating sources and sifting through the science. The pandemic has also allowed me to highlight the socially constructed nature of science-based recommendations, how the recommendations regarding COVID-19 arise not just from science but also from society. The recommendations and legislation around wearing a face mask, which have varied from continent to continent and also from state to state, can be seen to be inseparable from politics, economics, culture, values, and everything else that makes us human.

Nowhere has the COVID pandemic intersected more closely with our course topic than in the disruption it has caused to local and global food supply chains. On the bright side, one of my students suggested that the temporarily reduced availability of meat and higher prices might have been an incentive to prepare something other than meat for dinner. On the darker side, social inequities were revealed in meat processing plants, which were mandated to reopen and stay open during the pandemic. Statistics show that almost half of the COVID hotspots were linked to these plants, which disproportionately employ people of color, who tended to have poorer health outcomes if they contracted the disease.

Despite the challenges of teaching through COVID-19, there is room for optimism. Complex and capacious global crises such as COVID reveal that collaboration and cooperation are possible. More than that, they teach our students the importance of civic scientific literacy and the need for accurate information from multiple perspectives to solve perplexing and far-reaching problems. Teaching through COVID has helped me emphasize that as citizens in our globally connected world we can make a difference. If students want to do their bit for sustainability and other global issues to come, they need to integrate their learning and practice civic engagement by becoming critically thinking, engaged citizens.

UMB CURE Scholars Program Teaching Through COVID-19

Jatia Mills
University of Maryland, Baltimore

The Continuing Umbrella of Research Experiences (CURE) is a research training and career-development initiative funded by the National Cancer Institute, which focuses on building and sustaining a pipeline of students at various career levels, who come from groups shown to be underrepresented in biomedical sciences. The University of Maryland, Baltimore (UMB) is unique in being the first academic institution to focus on increasing the pool of underrepresented students in the West Baltimore area, beginning at the middle school level, to pursue science, healthcare, and broader STEM careers. The CURE program has a collective of eight dedicated middle school teachers and paraeducators who assist in building up and supporting their students in pursing their goals through scientific learning. Topics of learning include Anatomy, Chemistry/Food Science, and Coding/MESA/Robotics. Students are also provided the opportunity to present scientific posters at the CURE STEM EXPO and to compete with fellow scholars for prizes specific to their topic of study. The goal of this report was to gain a true understanding of what it was like for the middle school teachers and paraeducators of the UMB CURE to teach through COVID-19. This report represents the perspectives of a total of seven UMB CURE educators, including five phone interviews and two written statements, and details their experiences as teachers and paraeducators during the COVID-19 pandemic.

Technical Quandary

One of the greatest challenges of this current pandemic was the requirement that all learning be computer based. Several of our teachers and paraeducators expressed concerns about the students' lack of access to the internet. When interviewed about her challenges of teaching through COVID-19, one middle school science teacher stated, "Being in Baltimore City, many students struggled to obtain devices or working internet. Students who did have a working device often had to share it with other siblings." This seems to be a common theme among our CURE instructional staff and students. A CURE middle school special education teacher also worked with students in homes "with the only electronic device present being their cell phone and various other brothers and sisters using the device or internet connection; some still with no internet service at all." Even with these challenges, our CURE teachers and paraeducators, with support from the program, managed to go the distance in assisting students in adapting to this new wave of educating during a pandemic.

Making Adjustments in Teaching Style

Many of our CURE teachers and paraeducators found that they had to make major adjustments in their structure of teaching because of the COVID-19 pandemic. In an interview, a CURE teacher and UMB faculty member recalled the early days of teaching through the pandemic: "Initially, we tried to be very structured with classrooms. Here is your assignment for week by week. . . . Then we decided they were just too overwhelmed with their original classwork from their schools." From there, the teacher and her colleagues decided to take a different approach: "Let's give them merits for completing their work . . . and give them praise or shoutouts for completing work." They noticed that this created a boost in morale for the students and "[kept] the energy up." One middle school science teacher can also attest to the new requirements of teaching through the pandemic. When asked about the new structure of teaching through COVID-19 she commented, "I had to make real time adjustments and consider that some of my students still do not have at this moment access to technology or internet access so it forced me to not be so stringent with my demands in relation to when the students [could] turn in assignments. . . . It has opened my eyes and allowed me to be more flexible."

Another CURE teacher also realized the importance of "[making] time to celebrate scholars for their accomplishments, . . . and scholars react positively because they know how much it meant to do that work."

Going the Extra Mile

They have gone above and beyond by assisting students in finding internet access and even helping some of the students' parents, who were dealing with growing household costs. "When you think about the health disparities already in the city of Baltimore and the [lack of] access to health care, . . . knowing my scholars and their families are affected, it gets to my heart," a CURE teacher and UMB faculty member shared. One paraeducator explained that instructional staff have gone so far as to deliver food to families. "We have to make sure everybody is all right. . . . So if someone needs food, they send it so they can get it and wear protection." Although we are all taking responsibility for our own safety, it is evident that the support system within the CURE program has been beneficial to not only the CURE students, but the CURE parents/ caregivers and CURE instructional staff as well.

Student Growth

Some of our CURE teachers and paraeducators had a welcome surprise of an increase of curiosity in science inspired by the COVID-19 pandemic. One paraeducator, when commending her class, touched on how "we didn't know what it was at first but now they are getting a better understanding of what this virus is. But not just the virus, but of their projects on cancer and cancer of the lungs . . . and how it relates to their family members and [they] have learned so much and ... want to help their family." It is evident that these students have not only learned research skills but are now modeling the CURE program in actively engaging in community awareness of health disparities. Much like SENCER, the UMB CURE has proved to be an integral piece in the duty to encourage scientific civic engagement. In supporting these scholars, the CURE teachers and paraeducators have played a key role in the development of the next generation of scientists.

Reflection

Interviewing these teachers and paraeducators gave me great insight into the struggles of being a middle school educator and dealing with a pandemic all at once. I have learned that being an educator within Baltimore City can be a challenge in itself. Dealing with both a lack of support and resources has always been an uphill battle that these educators must somehow fight every day. From this experience I have a better understanding of what it takes to adapt in your work in order to progress. Although the work is hard, the middle school CURE teachers, paraeducators, and administrators have managed to do an excellent job of working together to ensure the success of their students.

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COVID-19 and the Political Context of Climate Change Solutions

Catherine N. Duckett
School of Science, Monmouth University
West Long Branch, NJ

As educators, we want students to be able to apply material to solve problems, possibly in novel situations. This spring, addressing the COVID-19 pandemic in class was imperative because of the social disruptions, but it also offered an opportunity to ask the students to transfer knowledge of social and political responses to the pandemic to other problems informed by science: in my case, climate change. At the time our campus closed, we were making a planned transition from focusing on climate science and technological solutions to climate crisis to discussing political solutions in my course, "Science and Politics of Climate Change," a senior-level interdisciplinary general education course with 22 students.

My students were near the epicenter of the COVID crisis at Monmouth University in New Jersey, which closed for spring break four days early because of an illness on campus. Consequently, they were paying attention. In the week before we returned to teaching, now fully online, scientists and journalists began writing about the COVID-19 pandemic, with some proposing solutions similar to actions that can help address the climate crisis, and I incorporated comparisons of these scientific and political solutions in class. This was, unexpectedly, a crashing success. Students were watching the news differently than previously, and the COVID crisis helped them apply what they were seeing and feeling to present and future climate problems and solutions.

At the beginning of the semester, most of my students were not paying attention to the news. I struggled to address my students' distaste for politics; a majority of them expressed in anonymous polling and in comments on Climate Interactive simulations that politics is "dirty" or "unpleasant," and therefore dangerous or undesirable to engage in. Students also believed that effective implementation of climate solutions was simply unbearably far away. Moreover, they had difficulty understanding systemic elements of climate injustice.

After the extended break, I made the course asynchronous and streamlined most assignments to free up emotional and intellectual "bandwidth" for the exigencies of the lockdown and other societal uncertainties. We began with one week of online discussions of COVID impacts on students, with explicit instructions to compare and contrast COVID to the climate crisis. I did not have high expectations about their performance or my abilities to leverage teaching COVID and climate for greater understanding. Because of the fast-moving and unsettled educational and social environment, I was simply aiming to assess the negative impacts of the COVID crisis on students and keep them engaged in the class.

To my surprise, student responses were very thoughtful. Middle-of-the-road students were more highly engaged with the material than they had been before break. All of the students in my class recognized that the COVID-19 response was analogous to a lack of political will to address climate change and many recognized the signature of science denial in both responses, which was something many in my class had struggled to accept and understand. (I obtained permission to quote student work after final grades were submitted.)

A Business major wrote:

> *The reading that I found more persuasive for this week was "Meet the Climate Science Deniers Who Downplayed COVID-19 Risks." Its focus was on the organizations and individuals who claimed the Coronavirus would not be as detrimental to society as it is. This reading also clearly connected the claims of these individuals with their retractions as things got worse. This makes me believe they are truly deniers of science.*

In the last four weeks of the course, we discussed political and technical solutions to climate crisis without specific attention to COVID. However, students continued to compare needed climate solutions to emissions results achieved in various areas because of COVID lockdowns and economic slowdown. Their comments were clear indications that they were paying attention to the news. More importantly, they identified political will on the part of individuals, corporations, and governments as critical to climate adaptation and mitigation successes. In the final exam, I asked, "What has the COVID-19 crisis taught us about the ability of societies to change quickly and forcefully? Can we apply these lessons to the climate crisis?"

Every student in class was very clear in answering this question: they believed that the forceful response to the COVID crisis indicates that societies do not prioritize the climate crisis. Comparisons of the COVID-19 response were personally galvanizing to several students and helped them to understand climate injustice as well. As a Marine Biology and Environmental Policy major wrote:

> *As devastating as the COVID-19 pandemic is, it revealed a lot of truths about our society and the way we conduct our lives. We are going to be able to use this valuable information in the fight for climate action. Never again, will we tolerate hearing that it is "impossible" to do anything. .... There is no longer an excuse for prioritizing the fossil fuel industry and the economy over the well-being of people.*

Most students embraced political action, some for the first time. A Psychology major, for example, wrote:

> *I have never been involved in politics because I think it is very messy and intimidating. However, it is important to be engaged in politics because who and what we vote for determines our future. I am going to research political leaders and proposals to gain knowledge on their values and goals and will vote for ones that align with what I think is best for our future. I will vote for people and proposals who have climate change plans as their top (if not first) priorities.*

Student responses made clear that because they were personally affected by COVID, which the widely quoted cognitive psychologist John Cook likened to "climate crisis on fast-forward," they paid more attention to politically motivated denial of climate science and were willing to reconsider their views on communal actions for the public good.

This raises the question: Does teaching through crisis, any crisis, help students focus on possible connections to the material? Or was this focus and understanding the result of specific parallels between COVID-19 and climate crisis? These questions remain unanswered, but my student responses have convinced me to continue to compare COVID and climate solutions next semester and to explore connections with any crisis in any semester more deeply.

Teaching Through COVID-19
Part I: COVID-19, Public, and Global Health: It's Personal

Barbara J. Engebretsen
Wayne State College
Wayne, NE

Introduction

The first week in March, I sent students off with my traditional spring break advice, "Rest, refresh, and return, ready to finish well." Only this year instead of adding, "and be good," I quoted a Johns Hopkins tweet much to their surprised amusement, "and wash your *damn* hands." Beginning in January, as a professor teaching Introduction to Personal, Public, and Global Health (PGH 200), I had been following and occasionally discussing in classes the developing news of the novel coronavirus. When I took students to the Midwest Global Health Conference at Creighton University in mid-February, we attended an update on the status of and preparedness for the "2019 Novel Coronavirus" by Dr. Sharon Medcalf of the UNMC College of Public Health and Biocontainment Center. Though aware of the seriousness of the quickly developing pandemic, none of us dreamed this would be the last time we would be together.

That week before spring break, the President's Council on Diversity (PCD) asked me to prepare a presentation on "COVID-19 and Xenophobia." As a physiologist, my evolution into public and global health was born of a growing disturbance to my professional homeostasis. The advancing sciences of non-communicable diseases (NCD) were not translating into healthier people. Indeed, the obesity and NCD epidemics were escalating, with a disproportionate preference for marginalized and vulnerable communities both domestically and globally. At the heart of my teaching philosophy is a desire to translate knowledge into action and change. In response to the PCD invitation, I suggested we assemble a panel to promote civil discussion and understanding, inviting a microbiologist and political scientist to join me. We began preparing for the panel over spring break.

By March 12, the college decided to prolong spring break for another week. The next day, they decided to transition all classes to remote delivery. My initial reaction combined emotional exhaustion with uncertainty. Everything had changed in a matter of days. Thoughts of graduating seniors, and international students indefinitely trapped in the USA or prematurely taking the earliest flight out, tempted me to give up. I considered calling the semester done, assigning grades earned by that time. For a few days, I was overwhelmed with immobilizing grief.

But grief for me has a way of weaving passion into action, daring me to "get off the couch" and do something. This humble reflection articulates how COVID-19 has reminded me that as a teacher, I am foremost and forever a student, learning for, with, and from my students. In Part II, you will hear some of their remarkable stories.

Teaching, Learning, and Moving Forward Through COVID-19

Three principles guided the revision of PGH 200 to remote delivery: First, I was acutely aware that if I was wrestling with complex emotions and logistical issues related to these unprecedented challenges, students would be as well. And so I made it a priority to be available, supportive, and flexible. Second, I wanted to maintain the academic integrity of my classes, so that in completing this revised semester, students would have an understanding of course content equivalent to that of students from "non-COVID-19" semesters. Finally, I was faced with a daunting task—how would I incorporate the intimately relevant lessons we have all been living during this time of unprecedented historical significance into the revised PGH 200 class without overwhelming my students, or myself?

PGH 200 introduces students to basic epidemiology; global health and demographic transitions; and the biological, behavioral, environmental, and social determinants of personal and public health trajectories. Students had just finished reading *Mountains Beyond Mountains* (Kidder, 2003), gaining a glimpse of their privilege as they learned about health in Haiti. They had prepared service-learning projects to promote health literacy, advocacy, and healthy lifestyles at Wellness Fair and World Speech Day events when they returned from break. The course would conclude with units on environmental health and a summary informed by a Lancet Commission report titled "The Global Syndemic of Obesity, Undernutrition, and Climate Change" (Swinburn et al., 2019), examining the synergistic interactions of climate change, NCD, and emerging infections. For their capstone assignment, students would work in groups studying a global health issue, and would develop a proposal for a hypothetical $10,000 grant addressing the issue. A personal action plan would commit to improving their personal health, with an understanding of how it would impact public and global health.

After surveying students for their wellbeing, internet, and textbook access, I divided the COVID-driven course revisions (COREV) into five modules for each of the five remaining weeks before finals. Then I began to rebuild course content into the COREV modules to be posted at the beginning of each week, with assignments due by the end of the week. Each day I would be "present" and available in our Canvas Course site during our usual class times, posting announcements with assignments due, PGH 200 relevant news, discussion, and encouragement.

The first COREV module wrapped up unfinished business. World Speech Day and Wellness Fair being cancelled, students nevertheless wrote reflections on the preparatory work they had done and lessons learned, while I scrambled to revise and prepare materials for the remaining COREV modules. Modules Two and Four were abbreviated environmental health and global syndemic units. This allowed me time to research and synthesize the constantly evolving personal, public, and global health information on COVID-19 for Module Three, informing us all of the etiology of zoonotic viruses and the pathophysiology and epidemiology of COVID-19.

Module Five revised the Capstone-Personal Action Plan assignment from group to individual proposals. Each student would identify a people, place, and problem affected by COVID-19. Challenged to think how one person can make a difference, they explored resources for translating knowledge to action by addressing relief, rehabilitation, or development to respond to this pandemic, repair the damage it has caused, or prepare for future pandemics.

Even before the death of George Floyd ignited long-smoldering racial tensions, students were seeing that underlying social inequities have made too many people vulnerable to the damaging impacts of this pandemic. Moving forward, as one student said, "Every student will remember this time in their lives, and I believe you can draw on everyone's unique experiences to learn about preparing for the next pandemic." What we all must learn from COVID-19 will inform every course I teach in the future, hopefully preparing future leaders in my classes—nurturing relevance and understanding, and empowering action and change derived from knowledge.

"If you have some power, then your job is to empower somebody else." —Toni Morrison

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Teaching Through COVID-19
Part II: Personal, Public, and Global Health: Translating Knowledge to Action and Change

Barbara J. Engebretsen
Kelly Cech, Josephine Peitz, Edgar Muñoz, Tabitha Shonie
Wayne State College
Wayne, NE

"I can't breathe." In April 2020, this would have referred only to the acute respiratory distress of a COVID-19 patient. Now, perhaps forever, "I can't breathe" has taken on a darker meaning in our country and around the world. These unprecedented times of both COVID-19 and the current racial tensions may seem unrelated on the surface, but seen through the lens of one of our classes, Introduction to Personal, Public, and Global Health (PGH 200), we are discovering how connected these two topics really are. After learning about the science and epidemiology of COVID-19, we were required to study a "people, place, and problem" affected by COVID-19. The current global conversation about systemic racism has opened our eyes to how racial and socioeconomic disparities contribute to how COVID-19 affects different communities. Our final projects asked us, "What can one person do?" Here we share what we have learned, with ideas for action and hopes for change.

Navajo Nation – Tabitha Shonie

"Dik'os Ntsaaigii," is Navajo for "big cough." This is what the Navajo Nation calls COVID-19. Helping our elders understand what is happening is a challenge because of cultural and language barriers. COVID-19 has affected the world, but the significance of its impact on a community I grew up in hits hard. Native Americans make up around 20% of the COVID-19 deaths in Arizona, but overall they are fewer than 5% of the population. In one of the most developed countries in the world, indigenous people live on reservations in underdeveloped conditions. Lacking basic resources makes it hard for people on the reservation to follow CDC Guidelines. About 10% of Navajo people live without electricity, and almost 40% have no running water. Even in official health data, Native Americans are labeled "other," which basically means we are being eradicated from the records.

We grow up hearing stories from our elders. They tell us we are water; that water is life. I want to address all of the problems facing the Navajo people, but I will focus on water with respect for the cultures, traditions, and struggles of our people. I will partner with the Navajo Relief Fund, a branch of the Partnership with Native Americans to raise money for providing water access. Because cultural understanding and trust are critical for reaching more people, Partnership with Native Americans encourages participation from Navajo volunteers, empowering and creating trust. Personally, studying COVID-19 in this class helped me to teach and support my family during these difficult times.

Rural Nebraska Food Producers – Kelly Cech

Rural Nebraska isn't the most racially diverse region in America, and racism isn't a topic that is openly discussed, carrying a stigma much like mental health does. The death of George Floyd and protests occurring across America [make] this a critical time to learn, educate, and change. It will take cooperation, just as responding to COVID-19 has required cooperation. My hometown revolves around agriculture, small businesses, and community support. Farmers and agricultural businesses are essential workers with increased risk for exposure to COVID-19. Not only that, but COVID-19 struck right during planting season. The market uncertainty, the impact on small business owners, and the normal stresses of planting season have combined to amplify mental health issues such as depression and anxiety, which, like racism, are not discussed.

Concerns I addressed included increased risk of exposure to the virus, mental health issues, and the many high-risk elderly people in my community. Proposed solutions included making masks for essential workers, distributing hand sanitizer, and coordinating a food donation service through our local grocer. Because understanding is key to health, I planned to develop and distribute educational materials about mental health, and set up a buddy program to keep in touch with the elderly who were isolated at home.

Essential Workers in Food Processing Plants – Edgar Muñoz

In April, my hometown of Sioux City, IA recorded the highest daily increase in COVID-19 cases in the US. While the nation was recommending physical distancing, Sioux City's number one employer, Tyson Fresh Meats, remained open, even as cases continued to rise. Employees came to work even if they had symptoms of COVID-19, fearing they would lose their jobs. Many of these employees had no unemployment or sick leave benefits, making them vulnerable to employer demands and even abuses. Finally, community backlash forced Tyson to temporarily close for "deep cleaning." But was this enough?

Advocating for employee rights, I learned about ways to require employers to be more responsible for the health of their employees. Working with the Sioux City Community School District to provide meals for vulnerable families, I am also speaking out in support of hazard pay and benefits for essential workers. I will continue to advocate for hazard pay by attending meetings that discuss their health and welfare. Prior to COVID-19, I lacked an emotional connection with PGH 200 topics because I had never experienced them firsthand. The pandemic has made me see its impact on low-income families struggling to survive, children losing resources exclusively offered by public schools, and people mourning loved ones. It has inspired me to become more empathetic and aware when others worry about their health and wellbeing.

Domestic and Intimate Partner Violence – Josephine Peitz

Victims of abuse are often invisible, but the current protests are forcing us to think about all invisible victims of abuse as well as racism. Recently someone tweeted "couldn't be happier that I live in a small town in Nebraska," as if small rural towns aren't affected by racism or domestic abuse. This dismissal reveals a reality that perpetuates racist action and inaction. Racism begins as a "them/us" thinking when we need "us/we" thinking. Victims of domestic abuse are, likewise, often stereotyped as different than "us," and thus easy to ignore.

The lockdown from COVID-19 is possibly the worst situation imaginable for victims of domestic abuse. Being forced to stay home with their abusers, combined with the mental stress of lockdowns, unemployment, and fear, is having a synergistic effect on domestic abuse rates globally. One helpline source in England reported an increase of abuse calls by 49% three weeks after the lockdown began, and 150% increased website hits. Add to all this, slowed court proceedings, restricted health care access, and the closure of many domestic abuse shelters due to noncompliance with CDC guidelines; the conditions are perfect for abusers to further control their victims—physically, mentally, and financially.

Working with grassroots resources, I proposed ways of securing emergency shelter for abuse victims with donors and local hotels, and of developing a "code word" system for victims to reach out to kind-hearted people via social media for crisis intervention.

Concluding Thoughts

COVID-19 may have robbed us of time with friends, year-end closure, and graduation celebrations, but as one graduating student said, "COVID-19 has made this class the best learning opportunity of my college career. I have seen how personal, public, and global health becomes the focal point of everyone's life. It has given me confidence to make a difference and know the importance of taking action in a crisis."

We believe our class has shown that we have the potential and passion to navigate forward—translating knowledge to action, with the hope that we can change for the better and be better prepared for the next pandemic.

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Teaching Geoscience Tools for Addressing Societal Grand Challenges: A Unique Study-Away Experience During COVID-19

Lisa Gilbert
Williams College
Williamstown, MA

Summary

During the COVID-19 switch to remote learning in the Spring 2020 semester, I used the final six weeks of my oceanography course to teach specific topics and skills that would support students' ability to address complex, relevant problems. Students evaluated hazard and risk, worked with a variety of data, and learned the fundamentals of systems thinking. Much of the curricular material was based on published and peer-reviewed InTeGrate models, which were originally designed to be societally relevant. I introduced many of the examples and case studies originally planned, related to hurricanes, oil spills, and climate. Although I did not teach public health, human biology, or other topics more closely related to the global pandemic, students reported that the course was exceptionally relevant. They had the opportunity to apply knowledge and skills learned, but not all chose to do so. Assignments were tailored to give students choice, and while some students had a great desire to process the health crisis, many had limited tolerance for discussions of COVID-19 and saw class as one of their only breaks from news and household discussions.

Background: A Unique Study-Away Experience

During Spring 2020, 18 undergraduate students enrolled in the study-away program Williams-Mystic, the ocean and coastal studies semester of Williams College and Mystic Seaport. Students concurrently enrolled in courses on marine policy, maritime history, literature of the sea, and marine science. For their marine science requirement, students had a choice of two intermediate-level lab courses: my Oceanographic Processes course (n=11) and Marine Ecology (n=7). The semester had eight weeks of intensive, in-person learning beginning in January. After a week of introductory class meetings, we went to sea together for a research/training cruise on a tall ship for 11 days. Then we had another month of face-to-face classes and regional field trips. Students were living in four historic houses in Mystic, CT until mid-March, when they were sent home for six weeks of remote learning because of COVID-19.

Remote Learning Guiding Principles and Structure

In designing my remote learning materials and schedule, I applied two recommendations from colleagues who had taught online previously: be consistent and communicate more than you think you need to. I re-evaluated my course goals and selected activities that could help my students meet those goals in the new learning environment. I revised my statement of inclusion and facilitated a discussion of expectations with students during our first class Zoom meeting—not only what I expected of them and their expectations of me, but also their expectations of each other. In addition to meeting with my students once a week on Zoom, I decided that I would record a short video each week introducing the week's topic and post it on Sunday with the week's assignments. The video was intended to express my enthusiasm and empathy and answer the questions: (1) why this topic? (2) what are the expected learning outcomes this week?

Remote Learning Through COVID-19

I continued to teach oceanography and did not attempt to directly teach about COVID-19 in Spring 2020. However, I intentionally used the six weeks of remote learning to teach topics and skills that students could apply to complex societal problems. I prioritized activities that gave students opportunities to evaluate data, make predictions, practice science communication, and develop their systems thinking and modeling skills. Many of the activities

I used during remote learning were adapted from previously published and peer-reviewed InTeGrate modules, which are available online for free (http://serc.carleton.edu/integrate).

The first 2 weeks of remote learning were focused on hazard and risk. Before our first class Zoom meeting, students read a short New York Times article by Jared Diamond, "That Daily Shower Can Be a Killer" (https://www.nytimes.com/2013/01/29/science/jared-diamonds-guide-to-reducing-lifes-risks.html) and answered several questions meant to prepare them for discussion: (1) What resonates most with you about what the author has to say about risk, and (2) What do you disagree with, or have questions about? Most students connected the article to their own behaviors during COVID-19, and I was inspired to hear several of them describe the altruistic actions they were taking to reduce risks for others. I have taught this unit on hazard and risk for over a decade now, and it is typical for students to share personal stories from earthquakes, hurricanes, landslides, and automobile accidents. However, during Spring 2020, we were all experiencing drastic changes in our lives aimed at reducing risk, and the discussions we had about uncertainty in data—particularly in how to make decisions based on incomplete data—felt not just relevant, but urgent.

In the final four weeks, we focused on systems thinking skills. We began with systems thinking terminology and diagrams. After that introduction, students worked with models of the climate system. I assigned students to create a systems diagram (and later a dynamic model) of their choosing. Students made diagrams about the complexity of getting homework done at home while caring for others, about the factors contributing to and the effects of their lack of motivation, and about their decision-making process about whether or not to return to school in the fall. However, while some students had a great desire to process the health crisis, many had limited tolerance for discussions of COVID-19 and preferred to address other relevant issues such as how coastal tourism and fossil fuel emissions are related in a feedback loop, thinking ahead to when beaches are open again. By the fourth week of remote teaching, about one third of the class reported satisfaction with the balance of oceanography and COVID-19 discussions, one third was eager for even more opportunities to discuss COVID-19, and one third wanted less. I tried to balance all those needs as best I could by providing many choices for assignments.

By design, students at Williams-Mystic typically demonstrate interdisciplinary thinking and incorporate many academic disciplines into any class session. They learn about climate change science in the context of historic and on-going social injustice, climate policy, and climate fiction, and from the perspectives of many stakeholders. They also form a close-knit community from living and going to sea together. This semester, however, I was witness to a more thorough integration of the close social and learning community than in nearly two decades of teaching here. Students shared their motivations for reducing risk, showing exceptional altruism and empathy for their communities and for society, not in an office hour discussion over tea, but in the middle of a Zoom class discussion of data uncertainty. While I believe students' relationships with each other were inevitably limited by being physically distant, as were mine with them, there were some moments when the social and academic synergies were intensified during class online because in the final six weeks of the semester, those hours together were all that we had.

In Their Own Words: Students' Reflections on Remote Science Education

Rebecca Hardesty and Melinda Owens
with Rachel Bennett, Maricruz Gonzalez-Ramirez, Andrew Hosogai, and Catherine Kuh
University of California San Diego
San Diego, CA

Introduction

We planned the spring term of 2020 to be the culmination of a year-long project investigating biology education, and a celebration of four undergraduate students analyzing it. However, the COVID-19 pandemic forced an abrupt change of plans. Not only did the students have to move away from campus and switch to remote learning, they had to complete their research projects without the in-person support of the research team. Because of their developing expertise in science education research, these students are uniquely positioned to provide insight on the impact of the pandemic on teaching and learning. This reflection is a collaboration between the four students and their supervisors that is based on the students' written reflections on how the pandemic impacted their feelings about learning and theirvaluations of science.

About the Class

The four students enrolled in a Biology Education Research class to get course credit for their research as part of a large multi-campus project exploring teaching in STEM disciplines at the University of California. This course, like all UC San Diego courses in Spring, 2020 was conducted remotely. Part of the students' work, which could not be done remotely, was to conduct classroom observations of introductory biology courses at UC San Diego and prepare audio data for analysis. The other half of their work was to conduct original analysis, with mentorship, on the data the research team collected. The four students and their supervisor met virtually each week to receive feedback and guidance on how they would present their research as a 10–15-minute academic talk. They also met several times with the faculty advisor for the course, who was also a member of the research team.

Below are some of their reflections in their own words.

Valuing the Practical

> "More than ever, I want to learn more practical science that is useful in everyday life.... Previously, my learning science was dependent on course readings and lectures. Now I am actively searching through the resources introduced to me through my science courses to try to make sense of a topic that is still developing. It is reminding me of why I was interested in science in the first place, as I am able to read what interests me, and skim over what does not" (Rachel Bennett, Research Assistant, Biological Sciences).

> "This pandemic has really given me a lot of opportunities to work with the nuts and bolts of processing data, especially for scientific learning. I am enrolled in an upper division biology lab and since this lab is being conducted remotely, we are essentially just visualizing how we are going to be doing the experiments while focusing more on the data analysis. Since we are focused more on the data and not the actual lab techniques, I have learned a lot more about how to interpret data and how to rationalize specific findings. A bulk of our time has been directly analyzing past students' data and formulating our controls for our experiments. If anything, I was just reminded that scientific learning is not just conducting experiments but poring over data" (Andrew Hosogai, Research Assistant, Biological Sciences).

Losing Community, Finding Resiliency

"It is unfortunate that I am not able to attend lectures physically, [or to have] a learning environment to communicate with peers and collaborate with them in a much more meaningful manner. This within itself creates a sense of community which is not easily attained through online learning in the comfort of one's room. My overall learning experience during the pandemic has made me realize the resilience of science and the importance of it" (Maricruz Gonzalez-Ramirez, Research Assistant, Biological Sciences).

"It has made it a bit difficult to self-motivate to learn. Because classes are online, it's in a way made many students including me feel like there are little to no consequences for skipping lectures or not putting more time into studying for exams… [But positively, my research project] has made me more interested in scientific research, and I now plan on attending an experimental psychology PhD program after my undergraduate degree. I was able to see the way scientific research works and [had] the opportunity to dive deeply into a topic I'm personally interested in" (Catherine Kuh, Research Assistant, Biological Sciences).

"Ever since the COVID-19 pandemic, the amount of human contact I've had has been limited to my family, which has really made me realize how much I've missed interacting with other people… On a more personal level, I genuinely feel amazed at how many instructors have managed to adapt to this situation rather quickly and are able to still give meaningful lectures." (Andrew).

Belief in the Civic Value of Science

"I appreciate science for what it is, for what it can do, and for its limitations. It is more important than ever to recognize that science is a painstaking and time-consuming process. In fact, the value of science has only increased for me, as it becomes clearer every day what becomes of society when the world has incomplete understandings of a critical topic" (Rachel).

"I feel that my learning experiences during this pandemic have made me value science much more. Science is about breakthroughs—a mistake can lead to discovery and its purpose is to surpass and solve questions that are yet to be answered. Remote learning is different from what I was used to, but it has not hampered my beliefs in the value of science, rather, it has strengthened them" (Maricruz).

"I think many professors have taken the pandemic as an opportunity to educate their students on the nature of a virus and this virus specifically. If anything, this pandemic has shown me how important science is to public health, but how politicized and often neglected it is" (Catherine).

Final Thoughts

These students' dual position as learners and researchers provides them special insight into the pandemic's impact on science education. Their reflections remind us how crucial feelings of community are to undergraduates' learning experiences and how this has been lost during the pandemic. However, students have found renewed commitment to the societal value of science and motivation to pursue it out of intrinsic interest.

The First-Year Student in the Distance Learning Environment: Challenges and Opportunities

Reem Jaafar
LaGuardia Community College, City University of New York,
Queens, NY

The COVID-19 pandemic created a crisis in different sectors of society. Suddenly we found ourselves at a unique and pivotal point in academic history. Uncertainty, compounded with the abrupt change to distance learning, created anxiety among faculty, students, and staff alike. Fear and uneasiness were particularly pronounced among students in their first semester. I teach at a Hispanic-serving institution in the heart of Queens, New York—the epicenter of the pandemic. Most of our students are the first in their family to attend college, and some of them do not have access to the robust support system at home that students at residential colleges may enjoy.

All incoming students are expected to take a First-Year Seminar (FYS) course. I teach the course for the Liberal Arts, Math, and Science majors. Our semester starts in early March and ends the first week of June. We transitioned to distance learning eight days after the start of the semester. In an FYS course, we teach students the habits of mind of the major and the college. We also engage them in experiential science learning to boost retention and help them decide on a specific area of science to pursue. Their expectations and our plans got derailed early on. Although this class is not a hard-core science course, it exposes students to science topics, and helps them develop the habits of mind needed for college success.

First, I must admit that I was worried about this class the most. How can I give students a "smooth" first-year experience? After all, our lives are now controlled by factors none of us have ever experienced. Second, I do not know them well enough to be able to identify potential areas of struggles. Do the students have internet access? Do they have devices? Which students will need the most scaffolding? How will I translate some of the experiential learning opportunities to the virtual environment?

During the five-day instructional recess, I spent my time reaching out to students to make sure they had the technology available to attend classes, while at the same time rethinking the curriculum. Our college uses Blackboard and has a built-in platform (Blackboard Collaborate Ultra) to provide synchronous teaching. It became apparent that students in the FYS class were the ones who felt the most turbulence transitioning to the virtual environment. On the first day, attendance was around 60%. The Division of Students Affairs reached out to students who were missing and finally the class was running at 80% of its original enrollment.

I was wrestling with issues of training, available resources, and ideas on best practices for engagement. In addition to meeting synchronously, I asked students to use a chat app on their phone. The goal was to create a community of peers where students could connect. They started using it to discuss questions and concerns. In retrospect, students appreciated this aspect of communication and their ability to stay in touch with me and their peers. Once students developed a sense of the routine and adjusted to the technical aspect, I started thinking about the next challenge: as a strong advocate of civic engagement, how could I instill civic engagement in first-year students who have not yet had the opportunity to experience college life?

Every semester, we introduce Environmental Issues in Urban Ecology as part of the course, in collaboration with colleagues in the Math and the Natural Science Department. In particular, we learn about different types of pollution, the Air Quality Index, and more generally we brainstorm and research the impact of pollution on the quality of life and our responsibility for saving the planet.

I discussed my plans with my collaborators, and we decided to tackle the same topics in the virtual environment, and to collect data using online resources. I started the units by grouping students during the live sessions and assigning them a research question. This activity was possible in Blackboard Ultra by creating groups and allowing students to meet in separate virtual rooms. Then we regrouped and discussed some of the questions and expanded to talk about the impact of different pollutants on public health and the environment.

In a face-to-face class, students used meters to collect data for the pollutants NO_2, SO_2, and ozone at various locations around the LaGuardia campus while accounting for traffic patterns. In the virtual environment, we collected data on airnow.gov, and we studied the overall air quality around campus. We also looked at patterns over certain periods of time. Students were also required to compare the air quality around LaGuardia with another city nationwide and with a second city outside the United States. One of our core competencies is global learning, so it was important to tackle environmental problems from a global perspective. Students also read and analyzed articles to further the discussion on how human behavior has a global impact on the environment.

The transition has been challenging for everyone and certainly for first-year students. We generally serve a non-traditional student body, and I was proud to witness the resiliency of my students. This pandemic has tested our ability to adapt to other learning environments. Keeping a civic engagement component alive is necessary if we want to provide students with the skills needed to succeed in an evolving workplace.

Our students will eventually go into a specific math and science major, and the importance of preparing them for a world that requires critical thinking and careful analysis of claims cannot be overstated. I am grateful to have colleagues who see eye-to-eye on the need to keep experiential learning and civic engagement alive in these uncertain times. During my struggles, I reminded myself to continue living the college's mission to "educate and graduate one of the most diverse student populations in the country to become critical thinkers and socially responsible citizens who help to shape a rapidly evolving society." To continue moving forward, we must emerge from this crisis with our mission intact.

An Innovation-Driven Approach to Virtual Learning: Using the Foundry Model to Transition Online

Stephanie N. Jorgensen, J. Robby Sanders, and Pedro E. Arce
College of Engineering, Tennessee Technological University

Andrea Arce-Trigatti
College of Education, Tennessee Technological University

As members of the Renaissance Foundry Research Group—an innovation-driven learning educational research initiative—our mission is to better understand and contribute to active learning strategies across disciplines. Our courses therefore leverage the Renaissance Foundry Model (i.e., the Foundry)—a pedagogical platform anchored in knowledge acquisition and knowledge transfer paradigms that guide students to work collaboratively and iteratively towards the creation of a prototype of innovative technology (PIT) that addresses a real-world challenge (Arce et al., 2015). We were accustomed to an interactive, face-to-face environment, but the onset of the COVID-19 crisis required that we quickly adapt our teaching to an online learning space that captured the rich experiences inherent in these Foundry-guided classes. The following offers lessons learned from faculty reflections regarding this transition as it pertains to engineering education.

Lesson 1: Keep the Active Learning

During the transition to online learning due to COVID-19, I attended an important training session featuring design thinking, in which I discovered that online learning did NOT mean sacrificing course content, but rather presenting that course content in various contexts. I began to interpret common online mechanisms (e.g., discussion boards, videos) as potential Foundry-guided activities that would offer students the active learning aspects important in their development of an understanding of complex concepts in chemical engineering. Particularly successful was the design of a discussion board as a knowledge transfer activity intended to allow students to interact with one another regarding the knowledge they gained about flow meters in the week's knowledge acquisition module. In learning about the basic technical function of flow meters, students were introduced to various types of flow meters, each with multiple real-world functions. In the knowledge transfer activity, they were asked to research one type of flow meter that was presented in the knowledge acquisition module and post a 250-word statement regarding the application of that particular flow meter and how it functioned, utilizing the technical terms of that week's module. Each student was required to comment on at least three other posts within the discussion board. Comments indicated that students learned much about the various functions and applications of flow meters and how they operated. One comment reported that the student enjoyed the discussion board assignment as it allowed for real-world connections to the technical content presented in the course.

Lesson 2: Continuity Is Important

During the COVID-19 crisis, our course Transfer Sciences II (focused on momentum transfer) in Chemical Engineering was moved to an online platform. A large portion of this course is dedicated to students' team projects focused on identifying a challenge (related to the course content) that also shows social impact. This challenge needs to be resolved with the development of a PIT as suggested by the Foundry (Arce et al., 2015). The PIT in the on-campus version may include the manufacturing of an actual physical device by the team of students. As the identification of the challenge must be made by student teams, they need substantial coaching on the implementation of the Foundry, which is typically accomplished in weekly meetings. To facilitate the implementation of the online version, we transformed the PIT to the development of a proposal for such a physical device but maintained the coaching sessions via Zoom meetings, which were already scheduled in the on-campus version.

Consistent with the on-campus class format, the student teams needed to present a poster (now electronic) detailing key aspects of the project, to be evaluated by a team of judges (now virtually). Feedback from students indicated that this transformed format was extremely effective for the successful completion of the projects. In fact, the success rate from the teams compared to the last on-campus version was similar or better. The lesson learned is that maintaining a structure very similar to that of the on-campus course by leveraging virtual meetings helps students to maintain continuity in their learning and success.

Lesson 3: Working Together

Given a focus in our classes on innovation-driven learning (including team-based identification of a challenge and the development of PITs that are responsive to the challenge), a difficulty encountered is in completing our aggressive agenda within the constraints of a 15-week semester; we want to ensure that students acquire course-related content knowledge while also improving skills that will enable them to transfer that knowledge to real-world problems. Then, suddenly, instead of the original plan, that agenda needed to be completed in ten weeks of in-class time and five weeks of "oh-my-goodness-how-are-we-going-to-do-this-through-online interaction" time. We often communicate to students that an effective way to solve complex problems is to work together and to be committed to moving forward together to remove obstacles. The Foundry-guided process for challenge resolution involves phases of knowledge acquisition and knowledge transfer with constant improvement. In wondering how we were going to complete the semester and/or respond to new challenges moving forward, we should not forget the lessons that we try to impart to our students. We must work together to meet challenges and be determined to see the process through regardless of the level of complexity.

Concluding Thoughts

The following reflection from one of our members provides insight into initial thoughts and concerns about the virtual learning transition brought on by COVID-19: "As a faculty member, I often thought that utilizing online platforms to administer course concepts meant sacrificing the active learning activities that cement students' understanding of the concepts by having them practice those concepts in a physical example or activity." However, as noted by our lessons learned from this transition, this is not the case, particularly if platforms like the Foundry are leveraged to help maintain the spirit of active learning in a virtual environment. Moreover, in times of turmoil, teaching can be a wonderful opportunity to model perseverance in learning for students. In our lessons learned, an emphasis is placed on being flexible and being supportive, but most importantly, on being there for the students. The end result can be contagious . . . in a good way.

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Creative Tension in Teaching through COVID-19

Bob Kao
Heritage University
Toppenish, WA

Abstract

During the COVID-19 pandemic and the transition from in-person to virtual class and lab teaching, I share reflections on Parker Palmer's concept of creative tension in teaching, and how it has shaped the validation of students' voices during virtual community of scholars team presentations. In addition, I reflect on and share how the lives of scientists connect with the career pathways of undergraduates. Finally, I share how COVID-19 pandemic has shaped the concept of advocating for support of undergraduates during times of uncertainty.

As we live through the challenges of the COVID-19 pandemic and its impacts on teaching, I am reminded of the concept of creative tension in Parker Palmer's *The Courage to Teach*:

> Teaching and learning require a higher degree of awareness than we ordinarily possess—and awareness is always heightened when we are caught in creative tension. Paradox is another name for that tension, a way of holding opposites together that creates an electric charge that keeps us awake (Palmer, 2007, pp. 73–74).

As I reflect upon the transition from in-person to virtual classroom and lab teaching, I am reminded of one specific paradox outlined by Palmer: "The space should honor the 'little' stories of the students and the 'big' stories of the discipline and tradition" (Palmer, 2007, p. 74).

In what follows, I will share my experiences and reflections from the general biology and upper-level molecular cell biology course and lab during the past spring semester of 2020. For instance, in planning for end-of-the-semester virtual community of scholars team presentations, I reflected back on what was done in previous semesters, and I integrated culturally responsive teaching and the validation of the voices in each team's presentations (Gay, 2010; Bell & Bang, 2019; Cajete, 1999; Ross, 2016; Kao, 2018; Dewsbury& Brame, 2019; Tanner, 2013). I was aware of changes needed to adapt from in-person delivery into a virtual classroom space. During the virtual community of scholars presentations in general biology, our class utilized Padlet for comments and reflections after each presentation. Through moderating and deep listening, I would validate the team's insights and share undergraduates' future questions. I both validated the voices of each team and linked them to the interconnectedness of health and the environment as concentric concept circles.

Another example includes reflective writing on the lives of scientists in molecular cell biology. By applying the Scientist Spotlight approach (Schinske, Perkins, Snyder, Wyer, 2016) in molecular cell biology, I explicitly connected Dr. Mina Bissell's themes on how a "thinking outside the box" approach provided important insights into how microenvironment affects cell homeostasis and how changes in matrix proteins led to tumor cell growth (Bissell, 2016). In general biology with cell physiology emphasis, I shared Corbin Schuster's first-authored review paper on glial cell ecology (Schuster & Kao, 2020) and encouraged undergraduates to write an open-ended reflection in their team research proposal, dealing with the research questions they wish to pursue in the future in general biology course and lab settings.

At the start of each class we reflected on the interconnectedness between human health and our environment; I highlighted recent developments in COVID-19 research and discussed the molecular cell biology of how SARS-CoV-2 binds to Angiotensin Converting Enzyme 2 in type II alveolar epithelial cells as discussed in the peer-reviewed research paper by Hoffmann and colleagues (Hoffmann et al., 2020). As I think about future semesters, I plan to engage future microbiology and general biology courses in a multidimensional learning context. In microbiology courses at Heritage University, I plan to devote more attention to SARS-CoV-2 and why there is a spectrum of symptoms with COVID-19, as well as to the impact of the novel coronavirus on global health.

As a teacher, mentor, and advocate, I reflect on sadness and gratitude— during the pandemic, I deeply miss in-person discussions and students' team lab experiments, and at the same time I am thinking about opportunity: how can I help our undergraduates collect data and help them navigate the experimental design process and teach them how to analyze and evaluate data? When I am reminded of gratitude, I think about the connectedness between mind, body, and spirit when it comes to teaching in the physical spaces of the class and lab, and I realize that the virtual class and lab are also sacred spaces for learning.

During the COVID-19 pandemic, I have also learned about advocating in each moment for our first-generation Latinx and Native American and non-traditional undergraduates (Kao, 2020). Through each moment, I reflect back on heart-centered mindfulness, and through each moment, I then link these to both creative and reflective mindfulness to help maintain centeredness during a time of uncertainty.

In summary, as we navigate the current challenges during the COVID-19 pandemic, I am reminded of words from *The Scalpel and the Silver Bear*, the autobiography of the first Native American surgeon, Dr. Lori Arviso Alvord (Alvord and Cohen, 1999):

With beauty before me, there may I walk.

With beauty behind me, there may I walk.

With beauty above me, there may I walk.

With beauty below me, there may I walk.

With beauty all around me, there may I walk.

In beauty it is finished.

Blessing Way

May peace and beauty surround us as we continue our advocacy and support of our undergraduates in their educational pathways and journeys.

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"Let me introduce you to what is changing our world"

Caleb Kersey
Freed-Hardemann University
Henderson, TN

I teach several courses for biology majors, but I also teach a non-majors biology course called Principles of Biology. As those who have taught any general education class know, students often encounter difficulties in subject matters they perceive as irrelevant to their future occupations. Principles of Biology is full of students who begin the class struggling to find the relevancy of this class other than the fact that it fulfills a requirement.

I am fortunate to have been introduced to SENCER in 2013, and my attendance at the SENCER Summer Institute's annual meetings from 2014 to 2016 completely changed my approach in teaching not only Principles of Biology, but all of my classes. One of the many teaching tips and tools I became exposed to was the plethora of case studies available from the National Center for Case Study Teaching in Science (https://sciencecases.lib.buffalo.edu/). I started using case studies as a major part of my pedagogy for Principles of Biology. One particular case study I use is called "Decoding the Flu," authored by Norris Armstrong of the University of Georgia. I use this case study to teach concepts related to DNA, RNA, transcription and translation, and their application to our understanding different flu viral strains. My Principles of Biology class was scheduled to do this case study, but COVID-19 had other plans.

As our university grappled with decisions emerging from COVID-19, faculty were told we would have one more week before all in-class meetings would stop and the remainder of our semester would be taught online. We were advised to take a portion of our remaining meeting time to communicate to our students how the online transition would look, as well as the impact this change would have on the logistics of our planned class activities. I grappled with what I should spend my time on with my Principles of Biology class. Some students had already left the university. Some were not coming to class. I settled on my last meeting with Principles of Biology just being just an information session about future plans. I also knew that possibly at no other time in the history of these students' academic careers would the importance of biology be as relevant as it was now, as the impact of COVID-19 was being felt in their lives and around the world. I wanted to talk to the students about COVID-19, what we knew about it, and emerging research questions. It occurred to me that for a non-majors class, a background on coronaviruses and specifically emerging research might be overwhelming for our last meeting time. I prepared a coronavirus presentation just in case, but I did not know whether I would use it.

I had just finished explaining the changes for the remainder of the semester of Principles of Biology. I got several questions about the changes. After answering those questions, I was through with what I had planned. I did not have a strong read on whether the students would be up for a COVID-19 talk. These are non-majors. They generally want to get out of class as soon as possible. I asked the class if there was anything else they wanted to talk about. It was in that moment that a student raised his hand and said, "Can we just talk about the coronavirus?" After calming my internal excitement, I asked the class as a whole for a show of hands of those that wanted to talk about COVID-19. Almost the entire class raised their hands. These are moments a teacher lives for!

I opened up a document with the published genome of COVID-19 (https://www.ncbi.nlm.nih.gov/nuccore/MN908947) and said, "Let me introduce you to what is changing our world." We scrolled through the approximately 30,000 nucleotides of COVID-19's genome. A look of wonder and amazement spread on many students' faces. A question came. "How could something so small be causing something so big?" Many other questions came. I had modified Norris Armstrong's Decoding the Flu case study and renamed it Decoding COVID-19. We talked about the history of coronaviruses, and how our understanding of the genetic differences of COVID-19 would be important in understanding how this novel coronavirus functions. I used this case study to help introduce concepts related to the structure of nucleotides, the difference between DNA and RNA, transcription, translation, and the importance of protein structure on function. Later in the semester, I spent more time with the Decoding COVID-19 case study, slowly explaining and elaborating on the biological concepts mentioned above. It was a perfect opportunity to link what was happening in the world to the basic scientific understanding of viruses and genetics.

The last class meeting with my Principles of Biology class was a confirmation of what SENCER has been heralding since its creation. Teach through connection. My exposure to SENCER helped me be prepared to take advantage of the clear connection we all have with COVID-19. My plans are for all of my classes in the near future to be taught through application to COVID-19. I am thankful for what I've learned with SENCER, as it has positively impacted my teaching approach and helped me catalyze students' curiosity about the living world.

Chemistry Labs Without Access to Chemistry Laboratory Spaces

Eileen M. Kowalski
U.S. Military Academy at West Point
West Point, NY

Disclaimer
Information presented here is the opinion of the author and does not represent the opinion of the United States Military Academy at West Point, the U.S. Army, or the Department of Defense.

Introduction

Chemistry laboratories inherently have risks. We wear safety glasses or goggles to protect our eyes from foreign objects. We have lab coats, gloves, and hoods to minimize our exposure to chemicals. The COVID-19 pandemic presented a new risk, and the mitigation was remote instruction over the internet. As my colleagues and I adapted our labs to online instruction, I found myself coming back to strategies to minimize safety hazards. Many experiments we typically do in our labs did not translate to an online activity, and I needed to coach myself into accepting that the alternate assignments we developed on the fly were the best we could do under the circumstances. I kept reminding myself that no lab was worth illness or injury, including potential COVID-19 outbreaks.

Our students left for spring break and did not return. Although this was disruptive and sudden, it had the advantage that all our students had completed about half of each course's laboratories in person. Labs that were completed the week before spring break could be written up in lab reports, just as we would have done had our students returned to campus. For some of the remaining labs, we could rely on our students' previous experience to interpret data we gave them for those labs. Our students would be able to practice analyzing data and preparing reports, perhaps individually rather than in lab groups, but operating instruments and hands-on experience would not be possible.

Operating instruments and collecting data in lab is more than pushing the correct buttons in the correct sequence. Unexpected results in other people's data have easy explanations—uncalibrated instruments, inferior instruments, poor techniques, or careless work. Students often believe that their data will perfectly match theoretical predictions, with no missing or extraneous information. This belief persists until students generate their own unexpected results. Developing good technique takes practice, and practice was limited this semester without access to laboratory spaces.

In addition to missed hands-on experience during remote learning, we also lost many mentorship opportunities during labs. Our school does not have teaching assistants. When our students are doing labs, faculty have two hours to interact with students, listen to them, and mentor them. Some of this mentorship is minor. When liquid will not flow out of a separatory funnel, we remind the students to remove the stopper. In other cases, we correct mistakes the students might not realize they are making, and we can prevent them from repeating the mistakes they made on their pre-lab assignment. Often my responses to their questions model scientific thinking or help them learn to reason through what they are doing in lab. Giving the students a data set and being available online did not authentically reproduce the typical mentorship experience of an in-person lab.

How the courses changed

Second-semester General Chemistry students do some skill-building labs, and then they use those skills in a research mini-project. Before our students left for spring break, they had completed the skill-building labs and developed their research hypotheses. Unfortunately, the students could not return to the lab to investigate their hypotheses. Instead their professors gave them data that the students used to write their reports. The opportunities for our students to follow their curiosity and to try, fail, and try again in the lab were lost this semester.

Organic Chemistry students were unable to do the four-step sulfa drug capstone synthesis (Coppock et al., 2017). Typically, the students develop their procedures from four provided journal articles. After discussing their synthesis strategy with their professor, students adjust their strategies as necessary and then conduct their synthesis over six two-hour lab periods. These six periods were replaced with learning to search SciFinder for molecular structures, developing at least one alternate synthesis strategy, and discussing the relative merits of each strategy. In their lab reports students recommended a synthesis strategy and analyzed data collected in previous years.

Introduction to Analytical Chemistry ("Quant") students were unable to do their gas chromatography or fluorescence labs. They were also unable to do the individual lab practical at the end of the semester. The Quant professor replaced these experiences with chromatography and fluorescence data that the students used to individually write reports.

Second-semester seniors take a class called Advanced Chemistry Laboratory, in which they develop, plan, execute, and present results from four capstone projects. Planning the experiments, getting unexpected results, and conducting additional experiments are important aspects of this class. Before spring break, the students had completed two projects and begun data collection on a third. The professor for this class sent data files for the third project to the students. If students needed additional data points to round out their data sets, the professor collected data for them. The third project conducted remotely was fairly similar to what the students would have done had they returned to campus. For the fourth capstone project, hands-on data collection was not possible. Instead, students wrote individual term papers. Since individually authored student work is part of the documentation to maintain our American Chemical Society certification, the term papers will be helpful data points in our program assessment.

The Way Forward

For our students who have at least a year of school before graduation, we can use subsequent courses to remediate hands-on lab experiences. General Chemistry students who were unable to design experiments in their research mini-projects will have time to collect data, assess their results, and try again in Organic Chemistry and Advanced Chemistry Laboratory. Students who did not use the gas chromatographs in Quant will use them in Organic Chemistry and Instrumental Analysis. The interrelated nature of the five subdisciplines of Chemistry means that our courses are also interrelated, so that revisiting topics or instruments occurs naturally throughout the curriculum.

Some of the adaptations to our lab program may be used again in future in-person labs. For example, learning to search SciFinder using molecular structures and having our students write individual reports are adaptations that worked well. Other adaptations were disappointing. In each online lab our students learned valuable skills and got meaningful practice, but their experience was a faint echo of what they could have done in hands-on labs. Because our students come from all fifty of the United States and some of them live abroad, COVID-19 would have been among the infections that spread through our student body two weeks after spring break. Preventing a COVID-19 outbreak on our campus was definitely worth half a semester of improvised and modified laboratory experiences.

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Teaching Environmental Chemistry Through COVID

Stephen A. Mang
University of California Irvine
Irvine, CA

Like most universities in the United States, the University of California Irvine (UCI) delivered all classes remotely after the middle of March 2020. UCI uses the quarter system, so the entire Spring quarter was remote. This change presented a problem for senior chemistry majors who needed one more upper division laboratory class to graduate. Our department decided to offer a course in environmental chemistry that could be used to fulfill this requirement, since we could not offer labs. Thirty-four students enrolled in the course, some of whom were interested in environmental chemistry but most of whom just needed the class to graduate. I structured the class with two learning objectives: for students to learn about the chemistry of the environment and to apply that chemistry to real-world problems and advocate for solutions. Most will not become environmental chemists, but I hoped that they would be well prepared to discuss environmental issues with non-scientists.

I had two weeks from being assigned the course to the first day of Spring quarter. Some materials were provided by a colleague, but they had to be extensively supplemented to make the course suitable for remote delivery. I typically use an active learning style, which is hard to replicate in a remote course. Additionally, some students had moved to different time zones and even different countries, which meant that lectures had to be asynchronous if I did not want to ask some students to participate in course meetings at unreasonable hours. I incorporated synchronous discussion sections and Zoom office hours so that students could interact with instructors.

I organized the course into modules in the Canvas learning management system. The course began with two-week modules on the chemistry of air, water, and soil, followed by one-week modules on radioactivity and agriculture, and finally a 1.5-week module on geochemistry and fossil fuels. To adapt the modules for remote learning, I posted lecture slides and pre-recorded videos at the beginning of each week. In lieu of in-class activities, the students completed short reading quizzes on each scheduled lecture day. I used Canvas discussion boards for each module to replace an in-class participation grade. To promote civic engagement, I expanded assignments from the previous instructor who had required students to write Tweets occasionally; every module had at least one assignment where students either composed a Tweet based on a relevant article, or found someone else's relevant Tweet.

The first module (air) offered several opportunities to discuss civic engagement by scientists. In addition to the basics of atmospheric chemistry and the kinetics of atmospheric reactions, we looked at successful environmental regulations such as the Clean Air Act and the Montreal Protocol. We also discussed Sherwood Rowland, a founding member of the UCI chemistry department who won the Nobel Prize in Chemistry for discovering the mechanism of stratospheric ozone destruction by chlorofluorocarbons (CFCs) and whose work led to a successful global effort to limit CFC emissions. The COVID pandemic response in Orange County, where UCI is located, provided a useful context for thinking about these topics, as there was significant local resistance to science-informed public health interventions like mask-wearing and restaurant shutdowns (Fry, 2020).

The pandemic also provided a real-world example when we covered photochemical smog. UCI is located in the South Coast Air Basin (SoCAB), which has all of the conditions (NOx and volatile organics from vehicle emissions, sunlight, geography that minimizes air transport) for photochemical smog formation (Finlayson-Pitts & Pitts, 1999). Air quality in the SoCAB was much better than usual in late March and early April when fewer cars were on the road (McNeill, 2020). Combined, these two months had 14 days where the Air Quality Index (AQI) was under 25 for ozone and 17 days where the AQI was under 25 for fine particulate matter (PM2.5). In comparison, 2019 had only eight such days for each pollutant and 2018 had nine low-ozone days and three low-PM2.5 days in the same two months (AQICN, 2020). Satellite measurements, popular science articles, and pictures on social media confirmed that air in the SoCAB was much cleaner than usual, and that global emissions of NO_2 were lower than normal owing to factory shutdowns and reduced vehicle traffic (Wang & Su, 2020).

The last module of the class was supposed to cover the climate impacts of emissions from fossil fuels and strategies for mitigating those emissions. These topics provide extensive opportunities to discuss civic engagement by scientists, given their importance and the stark difference between the near-unanimity of scientists and the division among politicians and the public. The module was supposed to begin on May 28th. George Floyd had been killed in Minneapolis on May 25th, and by May 27th protests were widespread, including large demonstrations in nearby Los Angeles (Taylor, 2020). Under the circumstances, teaching students about the future consequences of carbon emissions, a topic that can be overwhelming for undergraduates, seemed insensitive (Kelly, 2017). Instead, I posted content for the last 1.5 weeks of the class but made all assignments optional, with no excuses necessary.

This was a missed opportunity. Considering the theme of racial injustice behind the protests, ideally, I would have adjusted quickly enough to talk about the numerous racial justice issues involved in the climate crisis (Emrich & Cutter, 2011; Hauer, Saunders, & Shtob, 2020; McKibben, 2020). Courses in environmental chemistry, atmospheric chemistry, or other topics related to climate change in Fall 2020 should address the climate justice movement and incorporate material related to the COVID pandemic. Educating students about the consequences of climate change and public health emergencies necessarily involves discussion of the outsized impact of those consequences on minority communities. This is also the case when discussing pollution and other topics at the intersection of environmental chemistry and policy. Social justice issues are often overlooked in STEM education (Madden, Wong, Vera Cruz, Olle, & Barnett, 2017), but the current historical moment gives us the opportunity to present a fuller picture of the effects of pollution and climate change and to prepare our students for informed civic engagement.

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College Teaching During the COVID-19 Pandemic

Janet Michello
LaGuardia Community College, City University of New York
Long Island City, NY

It seemed like COVID-19 came out of nowhere. One day college professors like myself were immersed in their usual teaching activities, and then in what seemed like a movie on fast-forward, we were home struggling with having to teach all courses remotely. It didn't matter whether students and professors were prepared for such a quick pedagogical about-face.

A new vocabulary quickly emerged. Words like "Zoom," "Blackboard Collaborate," asynchronous versus synchronous, etc. became part of our conversations with colleagues and students. Those of us who had at least some experience teaching hybrid and online courses began to assist professors with limited or no experience teaching remotely. Panic could be heard in their voices as they asked numerous questions about how to even begin teaching in a format alien to them. As the weeks passed, questions became less frequent and a degree of technological competence began to emerge. There seemed to be a "light at the end of the tunnel," but the gravity of the situation for many students was not yet clear to us.

And then the emails came. In what felt like a rapidly approaching avalanche, students began questioning just about everything—readings, assignments, quizzes, exams, papers, due dates, and more. Even though explicit instructions were given, students sent multiple and repetitive queries about important and mundane matters with an equal sense of urgency. As students struggled with their new reality, the confinement of the governor's stay-at-home orders began to take its toll. Students living in New York City frequently share small apartments or live with multiple family members. Little by little, students began announcing that they were ill. As one person became infected with the coronavirus, others in their same living quarters became infected too. One young international student was hospitalized for nearly a month, and although he physically recovered, he remained emotionally drained and never completed the course despite the extra time and support given. As I submitted his grade of F, I wished there were a special designation allowed so he wouldn't suffer the consequences of a failing grade. At the CUNY school where I teach, during the pandemic students were given the option of receiving a letter grade or a Pass/Fail grade; however, you need to successfully pass the course regardless of your selection. Another student sent emails telling me she was sick and didn't know what to do or where to go to get tested for COVID-19. I directed her to what I thought was the appropriate resource, but later that week she informed me that she was unable to get tested. When I asked her why she was denied testing, she replied that she was told to contact her family physician. Since the majority of students in the college where I teach are low-income, many do not have the luxury of having a family physician or even medical insurance. Fortunately, in the weeks that followed this situation changed since free testing sites opened for people with symptoms.

As revealed in the media during the coronavirus pandemic, lower-income people throughout the country were disproportionately affected, with the majority of them being people of color. Like the student described above, many have neither adequate access to medical care nor violation-free apartments. Both public and private housing in lower-income neighborhoods in New York City are riddled with housing violations such as holes in walls and ceilings, falling plaster, peeling paint, rodents, roaches, and lack of heat and hot water. How can you sing Happy Birthday twice while washing your hands with soap as recommended by the CDC when you don't have hot water?Early on in the pandemic New York City had a higher number of COVID-19 cases than any other city in the nation. Hospitals could not accommodate all the infected residents, and personal protective equipment was in short supply. This situation eventually improved, but the dire consequences remained. People died at an alarming rate, including students and family and friends of students. One thirty-one-year-old student living in the

Bronx entered a hospital because of the severity of his symptoms and within two days he was dead. Situations like this occurred over and over again. As caring professors, we found ourselves being more than just educators. Our enhanced roles provided additional support and flexibility for our students, including guidance for emerging issues. A problem that affected many students was lack of computers. Since everyone in a household now needed to use the one family computer, this became a major problem. Other students relied on computers at school, which were not available now that schools were closed. We were fortunate to be able to refer students to the pick-up locations of computers CUNY provided for students in need. Another problem, however, was lack of reliable internet connections.

In summary, in my three decades of college teaching, this past semester, Spring 2020, has been the most difficult. It isn't because of the additional responsibilities I had because of the COVID-19 pandemic; it was dealing with the hardships so many students faced. At times it was overwhelming, knowing there were multiple deaths in one family or reading about how sick students were. It was also realizing how few safety nets our students have and anticipating what the near future will bring. So many students and their parents lost their jobs. There is currently a moratorium on evictions but what will happen when it expires? Will we see more students and their families living in homeless shelters? This pandemic illuminated the economic, health, and quality of life disparities that have existed for too long in the United States of America. As a collective, we as college professors need to do more. We have the responsibility to devote more of our energies to the call for greater equity for all our students.

Informal STEM Education and Evaluation in the Time of COVID-19

Scott Randol and Chris Cardiel
Oregon Museum of Science and Industry
Portland, OR

Contributors (in alphabetical order):
Julie Allen, Marcie Benne, Patricia Brooke, Vicki Coats, Kim Deras, Annie Douglass, Imme Hüttmann, Alison Lowrie, Verónika Núñez

The Oregon Museum of Science and Industry (OMSI) is a national education leader in science, technology, engineering, and math (STEM). OMSI's mission is to inspire curiosity by creating engaging experiences for learners of all ages and backgrounds, foster experimentation and the exchange of ideas, and help people make informed choices. As an informal STEM education institution (ISEI), OMSI contributes to education locally and nationally through exhibits, programs, and education research and evaluation. Traditionally, this work involves direct input from learners and community partners into the development of educational experiences; however, the COVID-19 pandemic has necessitated new and innovative ways of supporting our civic and educational missions while respecting public health and social distancing guidelines. In this reflection, we describe how two ISEI projects funded by the National Science Foundation have changed practices in response to the pandemic, highlighting successes, addressing challenges, and sharing lessons learned through these efforts.

Snow: Museum Exhibit, Educational Outreach, and Learning Research is a collaboration between OMSI, the University of Alaska Fairbanks, and the Center for Research and Evaluation at COSI (Center of Science and Industry, Columbus, Ohio), and includes research, outreach programming, and development of a traveling exhibition. Prior to the COVID-19 pandemic, the project team was preparing for the construction of exhibit prototypes for visitors to evaluate; however, the pandemic rendered standard formative approaches impossible. Rather than simply delay project activities, project leaders strove to keep things moving, even with no direct access to visitors and with most staff working from home.

One example of the pivots made by the team involved a collaborative brainstorming activity that would typically have been conducted in a large-group workshop. Instead, the team implemented a process for using Google Slides, where individuals added their sketches, pictures, and ideas to a shared online slide deck; the consensus was that this approach was highly successful and did not sacrifice the creativity of in-person brainstorming. A second modification made to the project's approach related to the evaluation of exhibit prototypes with museum visitors. For one particular prototype, the final exhibit will feature a large screen displaying an animation of falling snow that will zoom in and provide additional scientific information as visitors approach. While the team could not test the physical prototype, they determined that families could evaluate the animation virtually, and they quickly crafted an evaluation study including a survey and Zoom interviews, both of which allowed participants to comment on the animation and related educational content.

The COVID-19 pandemic forced the *Snow* team to adopt new strategies for engaging with other staff and community members. While there were costs, including the loss of some of the depth and breadth that could be expected during a typical formative evaluation study, these experiences have illustrated benefits that the team hopes to maintain even after the pandemic. Specifically, these tools provide direction on educational experience development and show potential for attracting public audiences that have been historically underrepresented in OMSI's learning activities.

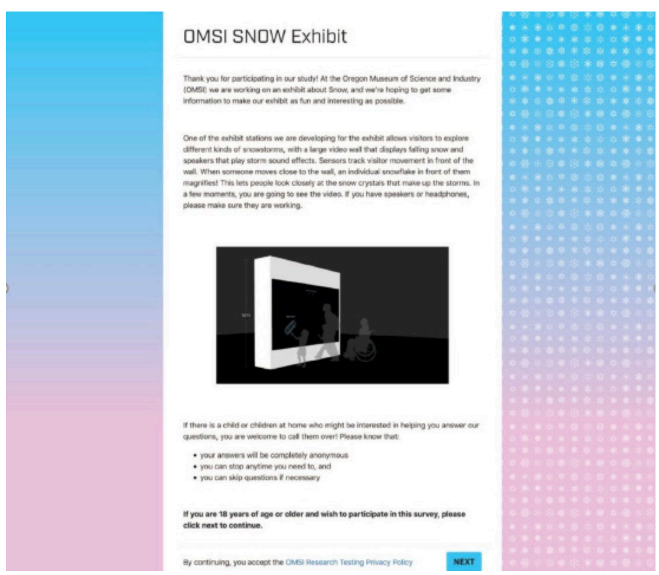
A second example is a family-focused STEM education program that engages educators, caregivers, and young children in an integrated set of experiences to foster interest in engineering design processes. Integral to the program are educator professional development and family take-home activity kits. In early spring 2020, the project team was preparing to deliver professional development workshops for educators and was planning to have families evaluate the hands-on activity kits through home visits and family nights at OMSI. It quickly became clear that, due to the COVID-19 pandemic, these activities could not proceed as planned. Online platforms such as Zoom made conducting professional development activities via teleconference a straightforward adjustment; however, more creative approaches were required to ensure families continued to influence the evaluation and development of the activity kits.

Traditionally, project staff would walk through activities with families gathered at OMSI or by taking activity kits, including necessary materials, to the participating families' homes. Educators would provide support and instructions for the activity while gathering input about how well the activities were working and what families thought of them. Without opportunity for live interaction, the team switched to creating instructional videos and sharing them through Class Dojo, an educational communication application that can translate content into 36 languages. Feedback on the activities is being gathered through a hyperlink included at the end of each video and through teachers involved in the program. The instructional videos solved the issue of how to explain the activities, but they introduced two additional challenges: materials and technology. Using materials that are familiar and readily available to families, though already a consideration when developing the kits, quickly became a necessity. Since kits could not be taken to families, the materials required for the activities needed to be things that families would have on hand. Additionally, the team needed to ensure that families had access to the technology required to view the videos; fortunately, the program was able to provide tablets/laptops to families who did not otherwise have access.

While the team missed the human connection with each other and with participating families, the crisis provided an opportunity to experiment with new approaches. Switching to more "everyday" materials in the kits allowed the families to explore the extent to which novel items contributed to the activities' success. Creating video lessons provided a long-lasting resource, while the team became more familiar with Class Dojo and gained skills in the production and use of instructional videos.

Quick and creative adjustments along with the leveraging of technology allowed the project teams to continue to progress with minimal disruption. Common in both examples was the implementation of new digital engagement strategies, both internally and with the public. While time-consuming to set up and implement, these strategies broadened the teams' skills and toolkits and ensured that experiences were collaboratively developed. In many ways these innovations brought people closer together through recognition that everyone was trying to do new and difficult things. Most importantly, the efforts sustained learners' participation and influence on the development of educational experiences that will benefit them and their communities.

Screenshot from the instructional video showing families how to use engineering activity kits.



Welcome page for the online evaluation of the Falling Snow interactive.

Distance Makes the Math Grow Stronger

Melanie Pivarski
Roosevelt University
Chicago, IL

It's funny how sometimes adding a bit of chaos to life can help one to focus.

Since 2015, Roosevelt University has taught a mathematics course where we partner with outside groups to analyze a mathematical problem of theirs. This class was originally developed with support from the Mathematical Association of America's PIC Math program (Preparation for Industrial Careers in Mathematical Sciences) (https://www.maa.org/programs-and-communities/professional-development/pic-math). At the start of the semester, one of our partners meets with the class to describe the setup of the problem. The students work throughout the term, and at the end of the semester the class presents their work as either a poster or a talk at our university's research day. Over time, we've had groups of students working on data on the spread of Ebola, on the University's energy use, and with biologists from the Field Museum of Chicago on their Microplants project.

The most fruitful partnership has been the one on the Microplants project, with Dr. Matt von Konrat from the Field Museum and Dr. Tom Campbell from Northeastern Illinois University. In this community science project, individuals measure the length and width of images of microscopic leaves, either at a kiosk in the museum or through a web portal. This has led to datasets from the touchscreen kiosk and from the Zooniverse website (http://microplants.zooniverse.org), as well as a file of demographic information on patrons using the kiosk. Each year students have looked at different aspects of the data, including kiosk usage, demographics, and accuracy (von Konrat et al., 2018). Due to the large quantity of data that have been collected over time and to the formatting of the data files, this has turned into a data science project in the past three years, with a lot of time devoted to data cleaning, processing, and formatting.

This spring, my class studied how to link the demographic file to the main kiosk data file, with a goal of seeing how age influenced the measurements. Were children better at this or were adults? I structured the class so that students would work in small groups on various aspects of the problem during class time, and I would wander about the room working with each group individually. We made good progress, and the data were aligned and in a manageable form more quickly than ever before. We drafted a talk on our preliminary work and planned to give it at our regional MAA meeting in mid-March. We made plans for a field trip to the Field Museum, where we could see the kiosk in person. We were excited by the many different possibilities in store for us!

We left for spring break. The MAA meeting and the Field trip were canceled and spring break was extended a week. The planning committee for our university research day had to rework the conference into an online format. I had to look at what we had accomplished as well as what we could do in a shorter semester. And, of course, as humans we all had to deal with the entirety of our reality; this wasn't just a change in our university lives, but rather a change in our whole lives. My students had many challenges to deal with; some had jobs whose schedules shifted due to the pandemic. Others had to share devices and bandwidth with their household. Others were still living in the dorms, but without the social connections of early March. With my husband's time filled by an emergency ventilator design project, I had to guide my first grader's study times as well as provide a social life for her. (She, too, adapted by deciding to marry our cat. It was a beautiful ceremony.)

With an overabundance of things to do, it was necessary for me to focus. But it was also essential to make sure that everyone was doing all right. I emailed my class to make sure that they could all use Zoom, and I set up a recurring meeting during our regularly scheduled class times. I told them that since the class was a simulation of what a data science job would be like, this transition to working from home was telecommuting. I assured them that I understood that they might need to miss class for a variety of reasons, such as work, illness, or family, and that this was perfectly fine; they just needed to email me when they were able to let me know. I told them that they had been doing great work so far, and that with everything that was going on I wasn't worried about how far we would get on this project. Everyone would get a good grade as long as they continued to participate. We wouldn't worry about a final exam. We would just do our best and see what we could do.

With the data in a good format, I split the class into groups of two or three, each responsible for one particular leaf image and its associated data. I had all of the groups do the same statistical analyses in parallel on Excel. This allowed me to run my Zoom meetings by starting with a short lecture, a demo of what they were to look at, and then I would split them into five breakout rooms to work together. I recorded the demo and typed out a summary after each class for people who had a schedule conflict. But to my delight, my students really stepped up their game! The quality of their work improved, attendance was great, and we made more progress than in the past semesters. Our biologist partners, freed from their ordinary schedules, joined some of our Zoom meetings. We ended the semester with a draft of a paper, which we're completing this summer. Rather than a pandemic pandemonium, we ended up with a CO   convergence.

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A Light at the End of the Tunnel

Ginger Reasonover
Lipscomb Academy
Nashville, TN

On the Wednesday before spring break, we found out that our students were being given the Friday before break as well. But not teachers! Due to the impending COVID-19 pandemic that nobody could have predicted, teachers were required to come to school to learn about virtual learning. After a day of what-ifs and maybes, teachers took enough materials home to plan for a possible extension of spring break. One, maybe two weeks, at most. We settled in thinking, "*We can do anything for a couple of weeks*."

Unfortunately, the pandemic worsened. Two weeks became four, four became six, six became nine.

Clearly, the words *Virtual School* can instill panic in the hearts and minds of most elementary school teachers. We miss the daily interaction with our students—hugs, smiles, conversations—but we also miss the interaction with our co-workers. As a hands-on science teacher, being told I had to teach online sent shivers down my spine. Our learning train had been derailed and it was up to me, the teacher, to get it back on the tracks! All my carefully orchestrated lesson plans now seemed useless.

I teach at a school where access to technology is not a problem for most students. Having access and having it work, however, are two different things. Teachers dealt with problems that arose from different learning platforms, device incompatibility, and additional obstacles; all had to be addressed before teaching could begin. Of course, some students enjoy *school* more than the actual learning and completion of assignments. When physically at the school building, surrounded by friends and teachers, many students subconsciously rely on peer support and pressure to accomplish required assignments. Once students had to control their learning through a computer, they missed school structure, and a few late-night phone calls and emails with concerned parents ensued. Difficulties were compounded for parents working from home. Having children in varying grades all vying for the computer while parents were trying to work was, at best, complicated, and definitely an exercise in patience for all concerned!

As for class content, considerable changes were made, as well as to delivery of said content. I put the "hands" in hands-on science! I knew students were not likely to have beakers, electricity kits, and chemicals at home, but I quickly learned that access to even the most basic materials might be problematic. Suddenly, I had to adapt not only my scope and sequence but also materials used in the labs themselves.

For example, to study the concept of sound with students, I first shared a video about transverse and longitudinal waves. What is the easiest way to demonstrate waves? Slinkys™ and jump ropes, of course! As a kid raised in the 60s, I played with Slinkys™ and jump ropes frequently. To my dismay, none of my students had a Slinky™, and most did not even have a jump rope. Had we been at school, this would not have been a problem—open the cabinet, and voilà!—there were the Slinkys™ and jump ropes. Teaching online sent me back to the drawing board. I found several simulations focusing on sound waves and even a few using echolocation (which we had studied earlier in a discussion of animals). I even traveled outside to film a video on sound mapping, posting it as an example for my students to use when recording their own sound mapping video. Using a piece of string and spoons to demonstrate sound vibrations, students listened to different sounds produced by changing the type of string they used.

Easy body movements helped students model wavelength, amplitude, crest, and trough. Incorporating literature, students listened to the book, *The Remarkable Farkle McBride* by John Lithgow (2000), and discussed different instruments.

Online quizzes and written assignments were required throughout the course. At the end of our study, students made homemade instruments from recyclable materials. They explained what type of instrument it was (percussion, woodwind, or string) and made a recording of themselves playing the instrument with at least two different pitches. Of course, drums and glasses filled with water were common, but some instruments stood out from the rest. One student worked with her grandfather to make a wooden "tuneboard." They sanded down the wood, drilled holes, added strings, and produced a beautiful instrument. Another student made a chipendani, a copy of an instrument from Zimbabwe, his family's native home.

Continuing through the semester, teaching became easier as I became more adept at changing materials required for lessons. When studying communication, I again relied on an online video and wrote an article to introduce concepts. We then talked about Morse code, and students decoded a message I sent to them. With our study of binary coding, students were assigned a message and asked to make a model using Cheerios™ (to represent 0's) and pretzel sticks (to represent 1's). Some students were highly creative in finding substitutions for Cheerios™ and pretzel sticks!

My journey into virtual learning was not one I will soon forget, nor one I look forward to repeating, although I'm certain we will. However, there were bright spots. I acquired new computer skills and am now hosting ZOOM™ meetings, recording videos, and using Flipgrid™ and Google Classroom™. Another benefit I experienced was growing closer to my students when working through the trial and error of computer learning. I have also expanded my "bag of tricks" and have gained some wonderful insights into my students' minds. So, while virtual school was not perfect, or even desirable at times, there are numerous ideas I will include in my lesson plans for next year because they added value to the educational process. I don't know what the future holds in regard to the pandemic or what our school year will look like in the fall, but I can now see the light at the end of the tunnel, and I am no longer afraid that it is an oncoming train!

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Keys for Project-Based Design in the COVID-19 Era

Lynn Ameen Rollins, Andrew Martin Rollins, and Kurt Ryan Rhoads
Case Western Reserve University
Cleveland, OH

This spring, the COVID-19 pandemic required universities across the United States to adjust their delivery of course content, find ways to evaluate students remotely, and in most cases, adjust to a student body no longer all living in the same time zone. While these challenges are significant for all courses, project-based design courses have an added degree of difficulty because interpersonal interaction is key to their success. Our Center for Engineering Action provides undergraduate students with opportunities to participate in multi-disciplinary team-based design projects, research, and coursework, which focus on advancing the public good through partnerships between local and global communities and Case Western Reserve University. All of our projects, both course-based and extracurricular, involve close communication with partners, and many involve international travel. The suspension of travel and the need for social distancing required new approaches to achieve our goals. We will briefly discuss five key attributes of projects that kept students engaged and how they impacted the adaption of project plans in response to COVID-19, based on our own reflections and student feedback.

Strong Connections with Community Partners

The connections among our teams and between the teams and their partners are the foundation of all project-based work. Teams that had a strong connection before the COVID disruption fared better than those that were still bonding. Our Engineers Without Borders (EWB) Dominican Republic team benefitted from a relationship with our community partner that has lasted for over a decade. The team was preparing to travel this August to install a drinking water chlorination tank. But, when travel was postponed due to the pandemic, the team pivoted to finding new needs in the community. On the recommendation of EWB-USA, they conducted a survey of their partner's needs in the wake of COVID-19. This resulted in a fundraising effort to acquire cloth face masks for the community. When our partner learned how much students raised, they texted a joyful reply translated as, "My God, you are my heroes!" As one student stated: "The opportunity to continue to support our community was refreshing, and I was really glad to help them in this time of great need."

Projects that Address Current Needs

As demonstrated above, adjusting plans can be the right decision when the needs of the community change. While working with vulnerable partners is not new to our students, COVID-19 presented a new, urgent need and also pointed out the urgency of existing needs. For example, our vaccine carrier and our pediatric pulse oximeter design teams were working on projects that were suddenly needed to address the current COVID-19 epidemic across the world, including our own communities. One student leader eloquently stated, "Framing our project work with an eye to the current world events and understanding how COVID-19 affects project work helped me feel more centered, because it made project work a way of feeling more in control despite everything that was going [on] in the world outside of my control."

Deadlines and Expectations

Deadlines and course incentives helped students stay focused when plans changed mid-semester. While we did our best to help all teams, students enrolled in courses maintained their projects better than students working extracurricularly. Even though courses transitioned to remote delivery and there were fewer face-to-face meetings, course office hours were held regularly with teams and reports were submitted on time. In contrast, students working extracurricularly always have to balance their project work with coursework, jobs, social activities, and other extracurricular work. Inevitably, extracurricular project work loses out.

A Strong Sense of Team

Team and advisor meetings were more important than ever as a mental health check-in, since we all found ourselves isolated and surrounded by bad news. Multiple students reported that what motivated them to keep working was knowing that their teammates were still doing work. They did not want to disappoint their peers. Student leaders tried to set a good example and be positive for their teams.

Making an Impact

With travel postponed and project plans in limbo, team members found it difficult to stay engaged and focused. Students were disappointed, especially when implementation plans that were years in the making were pushed back. Students who remained hopeful that their work would indeed have an impact remained engaged through all the plan adjustments. Our Malawi team, which was scheduled to install a solar power system at a national park this May, is instead organizing local professionals to install the system that the students designed. While the team was hoping to travel and install themselves, they now look forward to the community benefiting from their new solar system, to which everyone contributed. Knowing that the project would ultimately succeed countered their discouragement.

Conclusion

In summary, travel to our partner communities, with the opportunity to connect with them more deeply, as well as the deadlines that travel enforces, provides great motivation. But in this time of limited travel, we learned the importance of finding alternative motivators. Engagement can remain high when projects are built on strong partner relationships and address needs that are current and relevant. When projects are for credit, students are more able to prioritize them even when unexpected stressors emerge. Under stress, staying even more closely connected with teams through video meetings and emails was vital for the well-being of both projects and individuals. Having a well-defined problem, even if it means adjusting to new circumstances, helps teams see that their work will have an impact.

In some ways, the project disruptions have had a positive impact on how our center operates. As some activities have slowed down, we have had more time to reflect and make thoughtful decisions. Because all of our needs were changing, we also had more frequent meetings with our teams and partners, which strengthened our relationships.

Despite the challenges of this semester, our students unanimously feel hopeful concerning the future of their projects, and several students stated that this semester has taught them to be more compassionate, patient leaders. These traits are badly needed in our world today!

Teaching through COVID-19: Undergraduate Calculus Project on the Number of COVID-19 Cases

Sungwon Ahn
Roosevelt University, Chicago, IL

Each semester integral calculus students complete a semester-long project which serves Roosevelt University's dedication to social justice and civic issues and connects academic work to real-life problems (González-Arévalo & Pivarski, 2013). In Spring 2020, we provided a project to forecast the growing number of cases of coronavirus disease (COVID-19) using a logistic epidemic growth model with real data. During this project, students concurrently learned various integration techniques and basic concepts of ordinary differential equations behind the epidemic model presented in the textbook for the course (Hass, Heil, Weir, Zuleta Estrugo, & Thomas, 2019). Throughout the project, we expected that students would develop not only a deep academic understanding of calculus applied to epidemic modeling but also critical thinking, communication, and awareness of social issues.

The project consisted of four stages, each of which took a week or two: 1) a literature review on COVID-19, 2) introducing and developing epidemic models, 3) fitting the model to real data, and finally 4) a poster presentation. Each stage was characterized by a distinct set of questions with equal importance but which did not require extensive knowledge or techniques from the previous stage. For instance, the instructor evaluated the understanding of the background of COVID-19 and the readings at the first stage and evaluated computational skill with calculus in the second stage. At the end of each stage, groups wrote a separate report. In this way, the performance at each stage was evaluated independently so that students could avoid excessive work overloads at the end of the semester and keep their concentration throughout the lengthy project. Also, students communicated regularly within each group and found the best way for each of them to make a contribution at each stage.

For Stage 1, the instructor split the class into groups of four students. Initially, each group was asked by way of a warm-up exercise to find the definition of epidemic vs. endemic and the differences between them. The group conducted a literature review on the background of COVID-19 using external sources, answering a list of questions regarding for example causes, symptoms, geographic locations, prevention, and treatments of COVID-19. In addition to that, they choose a similar epidemic such as SARS, HIV, or MERS, and found similarities and differences between those past epidemics and COVID-19. We expected that this qualitative analysis would make the significance of COVID-19 clear to the students and motivate them to study the topic.

The class switched from in-person to online due to the COVID-19 at the beginning of the second stage. More detailed written instructions were provided, and follow-up group discussions were held online every Friday. Also, the instructor conducted Q&A sessions during the online office hour in order to minimize the impact of this radical change. The second stage took place after the class had learned various integration techniques and basic methods for solving a special type of first-order ordinary differential equation. The instructor introduced two popular population differential equations and their solutions: a logistic population growth model and an exponential population growth model. Students were asked to derive solutions using the two models and to analyze the differences. The class then explored an epidemic scenario in a simple but realistic setting with known parameters and initial conditions. Meanwhile, the class also learned basic syntax in Mathematica, including a visualization of graphs and creating functions. Students were asked to use Mathematica to respond to a list of questions, such as finding the shape of an epidemic curve and estimating the number of future infections. All the work was written and was evaluated as a report.

In the third stage, each group used outside sources to find actual historical data on the number of cases. Depending on their interests, the group could choose to find the number of cases from a local level to the global level. Then each group calculated appropriate parameters and an initial condition of a logistic population growth model to fit the historical data. The method for getting appropriate parameter values and the initial condition was developed and modified from Leonard Lipkin and David Smith's module (2004). Because coding in Mathematica is too complicated for students at this point, the instructor prepared sample code and gave the students step-by step-instructions for reading and understanding the algorithm. Thus students did not struggle with syntax errors, but instead spent time on getting the best parameters. At the end of this stage, each group had experienced the full process of mathematical modeling and wrote a report about the analysis of the epidemic curve and the forecast of future cases.

At the final stage, each group made a poster which incorporated all the results obtained from the previous stages. Sections in the poster included an introduction from Stage 1 and data and modeling from Stages 2 and 3. Also, the instructor asked each group to write a discussion of the advantages and limitations of the logistic model. The study of limitations proved to be particularly important, because the logistic model doesn't fit some actual data, especially at a local level. Some groups pointed out that the reason for the limitation is a lack of testing, the lengthy dormancy of the disease, and a lack of data. Once the posters were revised, they were presented in the online Roosevelt Student Research Symposium.

The benefit of this project was that it gave students an idea of how mathematical modeling with calculus can be used to make better predictions regarding ongoing issues. More than understanding mathematical concepts and solving a math problem, students came to appreciate the application of math to civic issues. Biology and chemistry students especially found this activity interesting, and enthusiastically communicated with their classmates to get better estimates. In the course of the project, we identified two main challenges. Even though each parameter in the model is adjustable to fit the data, the number of cases in some regions shows a non-logistic curve, for many known reasons. The positive side of the unexpected result, however, was that students discussed and identified the reason for the limitations of the logistic model, and then suggested alternatives, such as changing the model or data. The instructor could then ask students to summarize their creative alternatives for future studies. Secondly, students with little or no experience in programming had a hard time keeping up with the class in Stages 2 and 3. We believe that this difficulty can be handled with tutoring and by devoting more time in Stages 2 and 3 to the acquisition of programming skills.

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Democracy and Disruption: Science Education During a Pandemic

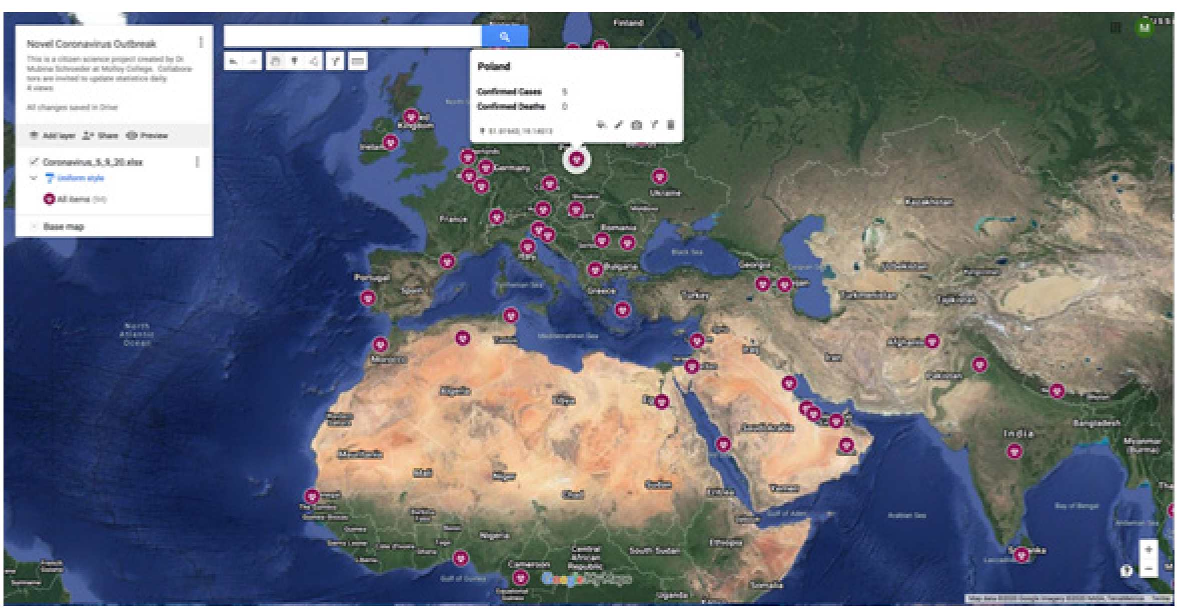
Mubina Schroeder
Molloy College
Rockville Centre, NY

We are living in uncharted times—some slivers of RNA have brought communities around the globe to their knees. Remarkable disruptions have unfolded in our daily lives, and communication from leadership about the factors involved with the outbreak have been nubilous and disjointed at best. The pandemic has laid bare the problematic issues in our society: inequality, injustice, and a lack of sound leaders. For instance, while our political leaders rushed to thwart economic decline, they largely missed addressing the other, crucial form of capital that is being deeply affected: knowledge capital. Pierre Bordieu (1984) described the different types of capital that circulate in our societies and said that cultural capital encompasses knowledge and skills that individuals use to scale barriers in society. Cultural capital and the knowledge capital it encapsulates is a road to equity, and I've found that giving students agency over their knowledge capital via citizen science has been critical during this time of upheaval.

My first presentation about citizen science was at the 2017 Science Education for New Civic Engagements and Responsibilities (SENCER) Mid-Atlantic Regional Conference, where I lauded its positive aspects for science education during. Citizen science, with its innate democratic underpinnings, offers a way for any member of the public to meaningfully enrich the scientific endeavor. I did not expect that citizen science would prove to be so salient as a tool in my science education classrooms as we faced the turmoil associated with the pandemic.

When the disruptions from the pandemic first started manifesting themselves in our lives, many of my science education students, most of whom were pre-service teachers, seemed apprehensive during class. To address the anxieties surrounding the outbreak and to engage them in a shared project, I created a collaborative Google Map that housed real-time data points about the virus' infection numbers across the globe (see Figure 1 below). Students in the class could update the data parameters, and many added data points such as school closures, and

FIGURE 1. Live map generated by college science education students at Molloy College



partial or total community shutdown measures. Unexpectedly, students worked fervently on the map and shared it widely within their networks. When I questioned them as to why they engaged so actively with the project, one student said that participating in the map project helped him feel like he had some control over understanding the outbreak and that he was contributing to the knowledge base about it. These sentiments align directly with the concept of citizen science and its democratic approach to creating knowledge capital.

Additionally, in the initial weeks of online learning in March 2020, science education students in my courses were asked to create a digital storytelling project about their experiences with COVID-19 and how it consociates with their ideas about science investigation and discovery. In my pedagogical approach, storytelling symbolizes an egalitarian avenue for understanding diverse experiences (Alterio & McDrury, 2003). During the pandemic, however, storytelling has become a way for students to highlight how they used their science reasoning skills to help them make life-or-death decisions. One student did their presentation on how they use their own research and forum information to stay informed, feeling that official statements lacked verisimilitude: "I don't trust what they're saying about wearing masks because when I look at countries where they have the outbreak under control, people are wearing masks everywhere. Therefore, I have masks for myself and my family and we wear them anytime we go outside. My father has a lot of health issues and we can't take any risks because we live in a building where many of our neighbors are dying from this." This was during the period of time when the Centers for Disease Control (CDC) was broadcasting the futility of mask-wearing to affect the transmission of the virus or to provide protection from the virus. It later dawned on me that the student may have potentially been saving their father's life; not only that, but other students viewed the project and commented in the discussion forum that they were going to start making their own masks to wear. The ripple effects of one student's science research were enormous against the backdrop of the pandemic.

In my classrooms, teaching science during a pandemic has largely meant encouraging students to find knowledge for themselves and to be avid detectives in finding the truth. Analyzing the data associated with the outbreak or creating decisions based on personal research helps quell some of the anxiety; knowledge capital can give students a sense of agency in an unpredictable world. And on their end, science researchers have acknowledged the power of citizen science during this pandemic: the American Lung Association COVID-19 Citizen Science Study and the University of California San Francisco COVID-19 Health Record Data for Research are examples of recent successful citizen-science-based information campaigns. In the end, 2020 may be marked as the year that members of the public vetoed the status quo epistles and found truth for themselves. Citizen science is, undoubtedly, democracy in action.

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COVID-19 Connections: Anti-viral Teaching Strategy

J. Jordan Steel
United States Air Force Academy
Colorado Springs, CO

Abstract

The COVID-19 pandemic has resulted in a sense of disconnection. Students and instructors are physically separated from campus and are limited by social distancing and shelter-in-place orders. As the COVID-19 virus spreads across the globe, leaving devastating destruction in its wake, an "anti-viral" strategy is desperately needed in order to teach students and to allow them to remain connected to the professor, their peers, and the course content. This manuscript describes the author's attempt to develop a COVID-19 connection with his students and use an "anti-viral" strategy in transitioning to online teaching and learning.

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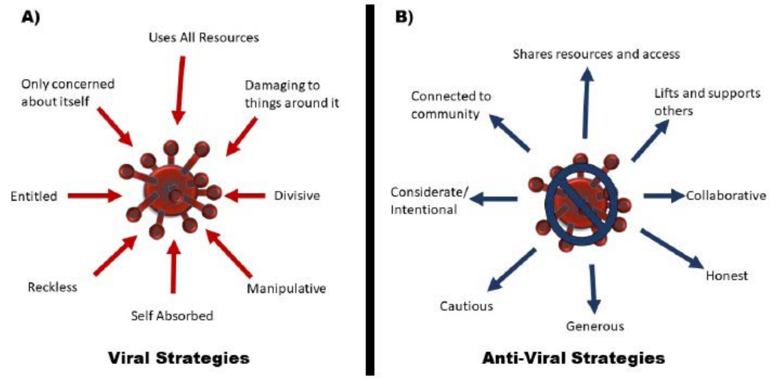
As biologist, parent, and teacher, I find that COVID-19 has disrupted every aspect of normalcy. Pre-COVID-19 meant long days, working in the microbiology lab, advising undergraduate research students, teaching college courses, meeting and advising students regarding course schedules and lifetime goals. Then COVID-19 hit. I am now at home, not allowed in the research lab, my students have been sent home to 18 different states, and I am trying to remember how to do long division as I homeschool my kids. Life is totally different, and teaching and connecting with students has changed. As I have reflected and tried to adapt quickly to teaching in an online format, I can't help but consider my teaching strategy "anti-viral."

Let me explain what I mean, as a microbiologist/virologist, by anti-viral teaching. Viruses are obligate intracellular parasites. By definition, viruses are lifeless, selfish, manipulative little protein shells that take everything they need from their host cells without regard to how their actions will impact the overall situation (Figure 1A). They are disconnected from anything bigger than themselves, which due to their incredibly small size, is basically everything. Viruses have been shown to take the host cell hostage and dominate and alter normal cellular physiology so that only the virus is happy, ultimately leading to the destruction of the host cell (El-Bacha et al., 2007; Fontaine, Sanchez, Camarda, & Lagunoff, 2014; Goodwin, Xu, & Munger, 2015; Sanchez & Lagunoff, 2015; Gullberg et al., 2018). Viruses have the smallest known genomes of all organized genetic material, but with that incredibly small genome, they can take over cells and cause massive multicellular organisms to fall and succumb to the infection (Belov & Sztul, 2014). So despite their small size, viruses' selfish nature can lead to massive destruction. SARSCoV2, the causative agent of COVID-19, has brought the world to its knees, caused economies to crash, and has ultimately taken the lives of thousands of people—all because of its disconnected and selfish nature. As a parent and educator, I want my children and students to have none of these qualities. I want to help students be connected to society as a whole and be contributing members of the global population who are actively trying to serve others, solve problems, and make the world a better place (Figure 1B). Hence, my "anti-viral" teaching strategy.

FIGURE 1. Diagram representing A) Viral strategies that are similar to viral replication and B) anti-viral strategies that are opposite of the virus and will hopefully enhance the learning environment during this COVID-19 pandemic



With my students being sent home and being spread across various time zones, it was difficult for us to connect with each other. I am a firm believer in active learning, group work, and student engagement with each other and the instructor, but in March 2020, higher education was suddenly thrown into a situation where social distancing and online learning seemed to prevent those interactions and inhibited connecting in person three times a week in class. Many students started to feel isolated, alone, and increasingly disconnected from me, their peers, and the course (Van Lancker & Parolin, 2020). As a novice online instructor, but an advocate for connection and relationships in higher education, I began fighting the negative impacts of COVID-19 by focusing "anti-viral" strategies around connection.

I focused first on my own connection with the students. Personalized emails were sent out to every student; the purpose of the main body of each email was to check in, express my confidence in the ability to still be successful in the course, and tell every student at least one thing that I appreciated/quality that I noticed from our time together. It was difficult and took some time, but I believe it is important for students to know that their professor knows them individually and believes in them. I gave each of them my cell phone number and told them that I was always a phone call or text away. I also highlighted my online office hours and encouraged them to come and talk to me in those video conferencing office hours as often as they could. I told them that I wanted to hear their stories and just talk about this crazy COVID-19 life. Many students replied and maintained regular contact through office hours for the rest of the semester. Those that I didn't see very often received second and third personal emails checking in throughout the semester.

The second task was making sure the students were connecting to each other. I began using Perusall, an online discussion platform for reading and commenting on course documents. Students were put into small groups and had the opportunity to communicate asynchronously regarding the assignments, or objectives, or the course in general. Students were required to connect and make at least five posts each week, which helped students remain connected with their peers. Their comments were not graded other than participation, and although I did see some great discussion about the course objectives, but I also saw just social commentary, memes, jokes, and group peer bonding that I value as an important part of being in a course and walking the same learning experience together.

Lastly, I wanted to ensure that my students were connected to the course content. In a traditional classroom, it is easy enough to watch students' faces and quickly realize who is lost, bored, or excited about the material. In an online format, it is easy to feel disconnected from that real-time feedback and formative assessment. I implemented more quizzes and simple online questions to help me understand what concepts the students were understanding and which objectives needed more time. I posted videos of me explaining the material as well as popular YouTube videos explaining different aspects of the material. I tried to have as many contact points as possible for the students to interact with the course material: online reading/discussion assignments, pre-class online quizzes, reflections, and practice problems. I implemented weekly reflections that provided an opportunity for the students to summarize the big picture learning points for the week and reflect on real-world applications. I tried to teach with COVID-19 examples as much as possible to help capture some of that genuine curiosity and turn it into true learning and scientific discovery.

Despite the complete change in life during the spring 2020 semester, by adopting a COVID-19 connection and an "anti-viral" strategy, I believe the students were able to maintain connection—with their instructor, their peers, and the course content—and that we were able to remain linked to the bigger picture and see past the COVID-19 pandemic.

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Dr. Seiser's Immunology Class or: How I Learned to Stop Worrying and Love the Textbook

Robert Seiser
Roosevelt University
Chicago, IL

Spring 2020 was my first semester teaching immunology. As a seasoned biology instructor and SENCER community member, I felt fairly well equipped to take on a new course prep (just stay "one lecture ahead of your students," they say) but faced the usual questions about the balance of content and context. Would I be prepared to navigate concepts that I hadn't focused on in decades? Would I be able to incorporate civic engagement and active learning pedagogies effectively? Would students be willing to commit to the process of learning and discovery that these pedagogies involve? Would I use multiple-choice exam questions?

After giving myself a crash course during the winter break and sorting out the syllabus, I started the semester with a simple plan. I would begin each week's class with a "science in the news" topic, something related to immunology that could incorporate relevant course topics and spur students—many of whom aspire to healthcare careers—to see the immune system at work in different aspects of human health. On January 27, the first day of class, I spent a few minutes on introductions, then showed a newly published electron micrograph of SARS-CoV2 and asked, "So, what have you heard about this emerging coronavirus?" After an informal discussion, I used one of my favorite resources, *Cell*'s SnapShots infographics, to introduce the immune response to viral infections and to lay the foundation for many of the course's main ideas.

Needless to say, I never had to pick another science news topic on which to focus. The start of each week's class became a time for all of us to compare notes on COVID-19 cases in Chicago, highlight new research, and bring our nascent understanding of immunology to bear on a real-life issue. And then, just before the spring break, our group of nearly 35 lost the ability to meet together in person. I faced a new set of questions about my class. Would I require everyone to participate in synchronous discussions? How and when would students get reliable information for their remote learning? What would I do about the scheduled end-of-term projects? Should I change the course format and teach everything through the lens of COVID-19?

After a few days of reflection and attempts to prepare for teaching from home, it became clear that the challenge was greater than sorting out logistics. The pandemic had become real for all of us, and all too real for those who work in hospitals and pharmacies, or who had family members at high risk. Several students faced significant challenges to financial security, internet access, and other requirements for full class participation. I sensed that they wanted to learn about the biology of the novel coronavirus, but in their academic work, they also wanted to have a sense of control and self-determination that they didn't feel in other aspects of their lives. If I made COVID-19 immunology into an all-encompassing course theme, my class might offer no refuge, no chance to get immersed in academic study for the purpose of planning a better future. On the contrary, it could be a constant reminder of the present challenge.

So I did something that I never thought I'd do again: I required everyone to make use of a textbook. The publisher of my recommended text granted free access to the online course site and e-book for the remainder of the term. I utilized interactive content, assigned online quizzes, and set flexible due dates. I followed up with students after quizzes and writing assignments, as a way to "check in" and make sure their needs were being met. I opened up breakout rooms in our weekly Zoom class meetings, ostensibly to discuss new course content but really to give students a chance to reconnect and interact with each other as they had when we were all on campus. And for the student presentations, I asked them to choose their own immunology topics. Tellingly, only one person chose SARS-CoV2, while the others drew inspiration from their own interests or from immune disorders mentioned in the textbook. By letting the authors and publisher of my chosen textbook take a greater role in the class, I had a little more time to find a new work-life balance, to prepare the concepts we would be discussing each week, and to incorporate news about COVID-19 as appropriate.

Much of my involvement with the SENCER project has focused on the "civic engagement" part of that acronym—bringing the world to students and equipping students to change the world. After Spring 2020, I better understand the "responsibilities." I realized that the unique opportunity afforded by teaching immunology in the midst of the COVID-19 pandemic carried with it two new responsibilities: first, to help my students make sense of the science and take an evidence-based approach to risk and decision-making. Second, to give my students a common set of tools, specific goals to meet, time to work toward those goals, and space to find their own balance during a time of disruption. It wasn't perfect, but I am proud of what we accomplished together and am grateful for their resilience. And maybe next time, I'll even require the textbook again.

Teaching Through COVID

Maria J. Serrano and Shazia Ahmed
Texas Woman's University
Denton, TX

Students and professors had different needs during this pandemic. We all think and react differently, and each learns in different ways. In retrospect, class content did not change. However, what changed was the delivery of information, presentation, and how professors adjusted while learning new tools.

We all had to leave our greatest fears behind and balance home and work environments that suddenly became one. We all had to work, cook, and manage a household that resembled a three-ring circus. That is why we had to become resilient by shortening the amount of time and space it takes between falling down and getting up, feeling bad and feeling better. We had to shorten the distance between our disbelief and believing in ourselves once again.

Teaching requires passion, patience, time, and effort. This pandemic demanded that we give only our very best and be creative with our time, and it gave us the wisdom and patience to counsel students so that they themselves could conquer their fears and accept their new reality. We no longer had the safety net of a nice routine that each of us had developed and perfected throughout several years of teaching. Suddenly, everything was not the same and we had to trade our classrooms and laboratories for a "home office," spare room, or some corner at home. This change was abrupt, and without the benefit of a grace period; it just happened.

The last few months we have felt like pilots of a flight that began with a very detailed plan; but while we were in midair everything changed and forced us to come up with a new plan. Some students were already experienced in taking online classes, while for others this was their first time using this learning interface. The first thing we did was to communicate how events were going to unfold with a lot more frequency and using different media to ensure that the message not only reached students, but that it was understood. We had to give them clear instructions about our journey, with clearly marked milestones, including a map telling us where we were and where we needed to go. We also had to convince our passengers (students) that everything was going to be fine and assure those who were afraid and confused that we were available day or night.

When you teach a class, you develop a relationship with students. You pick up on their energy and adjust lectures based on their feedback. When you record a video for them to watch online, you no longer have their energy, and you cannot change your delivery. The most frustrating part is that you don't know if what you just explained is clear. You no longer have the ability to ask them a simple question: "Is this clear?" You must deliver the message and use different strategies, such as online office hours, discussion boards, and FAQs, to see if they received the message as intended. Grades from tests and homework were going to be too late to make any meaningful adjustments. To address this, we performed surveys to gauge the efficacy of our approach to certain topics.

When you teach online you lose a vital connection that professors work so hard to establish in a classroom; even visual cues are enough to know if students are interested and if your message is getting through them. During online lectures we highlighted the key parts that students needed to learn from each subject. Also, we figured out that long lectures were going to backfire. It is very challenging to keep students engaged for a whole class. It is hard to imagine students sitting undisturbed in a dorm or home. Thus, we kept online lectures crisp, clear, and shorter than normal lectures. On the positive side, they can always rewind and watch again if they didn't get it the first time.

During this pandemic it was of paramount importance to have institutional support. Supervisors, university counselors, and colleagues at TWU were the control tower while professors were flying airplanes. They helped track progress and provided valuable advice and training when obstacles got in the way. Thanks to this support network, professors became expert at using online tools like Zoom, Panopto, and Canvas. Students had to become more disciplined, independent, and organized. As educators, our job was to help them get there by providing them with training and tools until they were self-sufficient. This was difficult, because students had to deal with unprecedented events affecting not only their studies, but their way of life, including relationships with families and friends.

This pandemic took everybody by surprise. There was no time to overthink; we had to act or react as best we could. We realized that the best way for our students to succeed was to learn more about the changes in their environment. Thus, as part of our Neuroanatomy class, we asked students to find out more about COVID-19, how it is transmitted, forms of treatment, and possible outcomes related to the neurological system. We believed that students could deal with this extraordinary situation more effectively if they were more knowledgeable. Another benefit was that they became more informed members of our community by understanding basic principles of virology. And by taking care of their own health and wellbeing they could also educate others. Furthermore, they would follow government regulations during the lockdown; not because the governor said they must, but because they truly understood why these measures needed to be taken. They needed to know that a virus is not just a disease described in a chapter in their textbooks, that viruses are real and can profoundly affect peoples' lives. Many students will become professionals in hospitals, doctor's offices, laboratories, etc. We asked students to think like patients. This is very important because we must develop students who are competent professionals and who also truly care for the well-being of their patients. This pandemic has changed our world, and whenever we felt exhausted, all we had to remember was that we are educating the people who will fight the next pandemic. That was enough motivation to get us moving again.

Teaching Through COVID: Navigating Uncharted Waters

Mangala Tawde
Queensborough Community College, City University of New York
Bayside, Queens, NY

Queensborough CC (QCC), CUNY is located in Queens, in the heart of New York City. Queens is one of the most diverse communities in the city, and QCC's students, faculty, and staff represent a beautiful amalgamation of over 50 diverse ethnicities, cultures, and spoken languages. By the end of February the spring semester was in full swing at QCC, and we were looking forward to the upcoming spring break in late March–early April, making plans for a family vacation. The scanty news of the coronavirus outbreak in China and other parts of the world had just started to trickle in.

Concern started to rise as the first confirmed case of COVID-19 in New York City was announced and the QCC/CUNY administration started sending emails about having a backup plan in case we had to "go online." It still sounded like a far-off possibility since "online education" was always looked down upon. However, as the grim reality of the severity of the spread of COVID-19 started to emerge, suddenly "going online" became an emergency. Though I had been teaching a partially online (PNET) microbiology class for few years, we had never thought of ever teaching completely synchronous classes. The College started offering training sessions on various platforms such as Blackboard Collaborate, Webex, and Zoom.

On March 12 CUNY announced that for the following two weeks—until spring break—all classes would be taught online. Though the first natural response was panic, faculty and staff sprang into action to get ready to start teaching online. Instructors, course coordinators, and other admin staff had meetings to decide on a course of action, and various online resources started to pour in. I teach human anatomy and physiology and microbiology, the pre-allied health courses, and coordinate the microbiology course. Getting myself acquainted with online teaching modality was urgent; bringing my not-so-tech-savvy colleagues onboard with new technological advances was another challenge. However, as they say, you learn to swim when you fall into the water; the team spirit emerged and we started sharing not only our panic, fears, and concerns, we started helping each other to come out as a strong face for our students who were confronting worse fears and situations.

As we started teaching, in front of our laptop cameras, trying to put on a brave face for our students, some grim realities started to emerge on the other end. Even during normal semesters our classes suffer from a 20–30% withdrawal rate. Now, we saw a sharp decline in attendance for several reasons: non-traditional students being unfamiliar with online learning, inaccessibility of computers or tablets, loss of jobs, and change in their family situations. These difficulties were palpable across the laptop camera but there was very little that we could do to help, which was frustrating and sad. To alleviate the challenge for students who had no access to a proper computing device for learning in the online environment, CUNY announced a one-week "Recalibration Period," during which time tablets and small computers were distributed to students and staff who needed them.

Changes in the courses we taught were inevitable since face-to-face instruction was out of the question. The lecture components of the courses were least affected but the lab deliveries were the biggest challenge. Fortunately, for the microbiology and other biology labs, most of the hands-on skills were covered before we went online, and so the students did not seem to miss a lot in terms of their laboratory experience. Preparing the PowerPoint presentations and putting together relevant videos, animations, and any online activity that we could find for all the labs, however, was nothing less than a nightmare. The time used by students for performing experiments in the lab was replaced by watching videos and my utmost sincere efforts to explain how we "do things" in a real (not virtual) lab. It was nice to see that students expressed their disappointment for missing the experience. My conscious educator mind kept telling me that this was inadequate, but my civic sense pacified the educator; this was the best we could do for our students to keep them and all of us safe. Though they are missing the important hands-on experience, they are still learning through the videos and our talks delivered across many miles from the other end of the webcam. As part of the course grade, we embedded a homework assignment on COVID, where the students reflected on what their experience as a student was during the pandemic and what they faced as family or community, as well as how studying microbiology is relevant during these trying times. Reading these reflections has been inspiring and eye-opening to say the least.

As the classes continued, we learned more than we had asked for—we learned through talking to each other and realizing how everyone is in a different situation but still tied together by a common bond of being hit by a pandemic and being equally vulnerable to this mighty virus. Sadly, a few colleagues and friends succumbed to COVID too. Students shared their stories of sickness and death which were heart wrenching. Despair seemed to fill the world, though there would be some rays of hope here and there. A colleague shared her experience when the father of one of her students got ill with COVID and was taken to the hospital. She reached out to her class for help, and another student ,whose father worked at the same hospital, responded immediately, helping the student to establish contact between the sick father and worried family. These incidents were heartwarming and soul-lifting. Many of our students, still training to be nurses, volunteered at various NYC hospitals working back-to-back 12-hour shifts. This filled our hearts with pride and joy.

Now, we are on the other side of the mountain. We are accustomed to online teaching and learning. However, the fear of possible COVID-19 infection still looms large and we are unsure how the fall semester will look. But one thing for sure, WE—the human race—are tough, and we will fight this TOGETHER!

Molecular Cell Biology: New Challenges and New Relevance in a COVID-19 World

Brian P. Teague and James B. Burritt
University of Wisconsin–Stout
Menomonie, WI

The authors teach the lecture (JB) and laboratory (BT) sections of an advanced molecular cell biology course at the University of Wisconsin–Stout. UW–Stout is a polytechnic institution, and we pride ourselves on a student experience that is centered around student/instructor interactions in small classes and hands-on learning in laboratories. This model of instruction was upset by the COVID-19 pandemic, which necessitated an emergency transition to remote teaching and a mad scramble for new practices that accounted for the necessary physical distance while maintaining some semblance of sound pedagogy. These changes primarily affected the *content* of the course, its *delivery*, and our *assessment* of student learning. Student feedback indicated some unambiguous successes as well as some areas for continued improvement.

The COVID-19 pandemic brought us and our students a fresh context in which to learn about molecular cell biology, and we sought opportunities to incorporate that context into our teaching. For example, a major goal of the laboratory section is to familiarize students with some of the foundational methods that researchers use to understand the inner operations of cells. One of those methods, a common technique for measuring gene expression called qPCR, is also the basis for the molecular diagnostic the United States Center for Disease Control and Prevention used in the early days of the pandemic. To increase the relevance of students' learning about qPCR, BT designed a "paper" laboratory experience that required students to analyze some real (but renamed) data to find a patient who tested positive. Another laboratory was replaced with an assignment that introduced students to antibody-based methods before asking them to design an antibody-based rapid diagnostic for COVID-19. Such assignments also addressed learning goals around experimental design and data analysis, even though we could not meet in a laboratory to perform the experiments and generate the data. While some students appreciated the direct connection to current events, many expressed disappointment that their hands-on learning had been replaced with "just another set of assignments."

In addition to its effects on course content, the COVID-19 pandemic had a dramatic impact on how we delivered that content. For example, JB uses PowerPoint presentations in his lecture classes, and he had experimented with synchronous online delivery of those lectures while students and instructors were still on campus. However, as we moved to emergency remote teaching, it became clear that some students had insufficient internet access to participate in synchronous sessions, while others had schedules or home lives that would interfere with "attending" virtual class. These unacceptable inequities led to his adopting an asynchronous model, where he would record a voice-over to accompany the slides and then upload the narrated presentation to our learning management system. While creating these recordings was time-consuming, students responded positively to this format: a number expressed appreciation for the flexibility this approach provided, such as the ability to slow down or re-watch the lecture on their own time.

Finally, the pandemic prompted us to reconsider our notions around assessment of student learning. JB's summative assessments have traditionally consisted of multiple-choice and short-answer exams administered in class. This semester, he replaced them with longer essay-format exams, which students could complete over several days with the assistance of any inanimate online or printed material. Importantly, he limited student responses to no more than seven sentences, which allowed him to assess concept comprehension while keeping grading time reasonable. Student feedback was broadly encouraging: some were frustrated by the brevity required of them or the fact that not all the material they had learned was "covered" by the exam, but many appreciated the flexibility of the new format and the opportunity to demonstrate the depth of their understanding. At least one student also noted that this sidestepped the issues they had with internet access in an "online/proctored" exam in another of their courses.

In sum, adapting our advanced molecular cell biology course to emergency remote teaching required rethinking several of our pedagogical approaches. Some these will remain with us when we return to face-to-face instruction—for example, several students suggested that JB continue using the essay-based exam format, while BT will spend more effort situating his courses' topics in current events and societal context. This semester also underscores the challenges in replacing the residential higher education experience with an online one: when asked what factors impeded their success in this course, an overwhelming majority of our students responded with "lack of motivation." It's easy to imagine why: all at once, their community of dedicated learners and their real-time interactions with passionate instructors and their cutting-edge laboratory experiences were replaced by . . . a computer screen. We suggest that this both highlights the unique value of residential post-secondary education and challenges us to create online learning experiences that engage our students with the same intensity as in the classroom and the laboratory.

Critical Thinking and Data: Understanding the Intersections Between Communication and Mathematical Modeling

Anne M. Stone and Zeynep Teymuroglu
Rollins College
Winter Park, FL

Like everything else, higher-education curriculums will look different post-COVID-19. During this global health crisis, many of us have become daily consumers of science and math through news reporting and conversations with family, friends, and colleagues. Only a few months ago, we were watching the morning news to get information about the weather or political candidates, but today we are all drenched in the news media's COVID-19 coverage with heat maps, data accuracy, mathematical models, etc. Today, non-technical audiences are listening to journalists, broadcasters, and politicians talking about "flattening the curve," "exponential growth," and "risk factors." The students who sat through a math class thinking "When will I ever use exponential or logarithmic functions?" could never have predicted their knowledge would be so relevant. None of us, not even applied mathematics instructors who teach Susceptible-Infectives-Recovered (SIR Models) using Kermack-McKendrick analysis (1927), would have imagined that news anchors would be talking about the basic reproduction number, .

In March 2020, we developed a brand-new interdisciplinary course, Communicating Math in a Global Health Crisis, to be taught online during a four-week summer semester. The idea of designing and teaching an interdisciplinary course with a focus on the COVID-19 pandemic was motivated by the urgency of informing our non-math majors about basic mathematical modeling principles as they watch the COVID-19 news in a politicized environment. Our course was designed and taught with the SENCER approach (Burns, 2010) of facilitating and cultivating a community of learners who are committed to studying in an interdisciplinary environment with problem-based projects and socially relevant activities about COVID-19.

The course emphasized the importance of interdisciplinary work, particularly integrating data analysis and mathematical modeling with theories of communication, to better understand the current global health crisis. Students first learned about social determinants of health, in order to understand the context that frames so much of the news about COVID-19. We discussed how privilege comes in many forms and how structural inequities are often communicated in quantitative terms that can be confusing to a lay audience. Students also practiced epidemic models with activities and projects that addressed complex issues related to the spread of COVID-19, such as inequality in health, education, wealth distribution, or race/ethnicity issues. A series of assignments that intersect mathematical modeling and communication principles allowed the students to observe and analyze the ways in which math is communicated through various news outlets. Discussions of media artifacts led to conversations centered around questions like, "Who gets to be counted in the COVID-19 data?"; "If we see a table and/or an equation, does math anxiety make us change the channel?"; "Do we need a fancy graph to explain what to look for in the data?"; "Can we trust every graph we see on the news/internet?"; "Are the fancy graphs telling the truth?"; "When a report states, 'exponentially growing,' what does it mean?"; and "Can you sustain an exponential growth for a long time?"

In a media log project, we gave students the opportunity to keep up with current news stories and record examples of message framing and various theories of communication and media studies in action. The students shared what they were reading, making note of how mathematical modeling was communicated in terms of predictions and mitigating or increasing risk. We also asked the students to interview each other to show the contrast between quantitative research with large data sets and qualitative, interview-based research that gives a more detailed sense of how the media are experienced during the pandemic.

Our limited experience with online teaching during the second half of the spring semester showed us that fostering student participation in remote teaching might present a challenge. We met that challenge using a variety of strategies including using the think, pair, and share method as students discussed the intersectionality of qualitative and quantitative methods. More often than not, we asked students to lead class discussions and engaged them with open-ended questions based on readings and current events. As we all were (and continue to be) bombarded with the news media's COVID-19 coverage in such a polarized environment, our course provided a safe space for students to share their thoughts, voice their concerns freely, and learn how to develop a critical eye for analyzing and assessing information in order to increase the knowledge and skills that are essential for making informed decisions about both their health and communicating about COVID-19.

Learning Resources for Communicating Math in a Global Health Crisis

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Making Lemonade: Adapting Project-Based Learning in the Era of COVID

Bridget G. Trogden and David Vaughn
Clemson University, Clemson, SC

Overview

As the pre-Socratic philosopher Heraclitus reminds us, everything in life is flux. What was true in 500 BCE is still abundantly true in 2020 CE. In particular, those of us working at the higher-education crossroads of science education and civic engagement have had to adjust and adjust again as we have rolled with the collective punches of travel bans, student recalls, campus closures, online teaching, and massive anxiety, stress, loss of income, illness, and death impacting our campus and broader communities.

In this article, we wish to reflect upon and provide insight into ways that we adapted a signature program at Clemson University (Clemson Engineers for Developing Countries) to maintain a high bar of student learning through the COVID impacts. Students, instructors, and community partners—despite setbacks—were able to access previously untapped strengths in the areas of initiative, independence, resilience, and creativity.

Engagement by Design

Clemson Engineers for Developing Countries (CEDC) was created in 2009, when groups of engineering students began long-term projects to develop and maintain a municipal water system in rural and mountainous Cange, Haiti. In the intervening time, CEDC evolved into a dual-nature structure as both a service-learning organization and a one-hour research course enrolling between 80–100 undergraduate students per semester across every undergraduate College and over thirty majors.

CEDC students work with Cange-based community partners at one of three levels of engagement: (a) project-based learning (all students), (b) place-based trips to Cange during University breaks (~12 students per year), or (c) field placement of resident interns in Cange year-round (two to four interns per year) (CEDC, 2020).

CEDC operates with a faculty program director who oversees the projects and the course elements. The faculty director is supported by a student program director, student functional area directors, and student

FIGURE 1. View of mountains from Zanmi Lasante Compound in Cange, Haiti

project directors, all elected annually by the students in the course. Industry experts frequently work with project teams to provide support and guidance.

Engagement by (Re)Design: The First Pivot Due to Localized Civil Unrest

Civil unrest in Haiti in the spring of 2019 prompted the first major challenge to the CEDC structure, when the U.S. Department of State issued a travel ban to Haiti. All Clemson interns in Cange were recalled and future place-based trips became uncertain. At the same time, conversations were occurring institution-wide about the ways that a public, land-grant, R01 institution such as Clemson University should and could engage the world.

CEDC underwent a change in scope, not only to support ongoing commitments in Cange, but also to identify and mitigate multidisciplinary community-based needs on a regional, state, and local level. The one-hour course was restructured to educate students on UN Sustainable Development Goals (Division for SDG, 2020), centering on one SDG per week. Additionally, student project units started using the Microsoft Teams software for collaborating and sharing project deliverables in real time and asynchronously.

Engagement by (Further Re)Design: The Second Pivot Due to Worldwide Health Crisis

The revised CEDC operational infrastructure made the impacts of the Spring 2020 COVID-related adjustments much less difficult. The CEDC faculty and student leaders created a Continuity of Operations Plan (COOP) in early March of 2020, which was put into effect on March 23 when classes resumed after spring break (Nejman, Malvoso, & Smith, 2020).

The course typically meets for two hours on Friday afternoons for a combination of lecture-based learning and team-based learning on projects; program directors meet throughout the week to help push projects forward and prepare for the next class. The COOP delineated a revised structure, where the first hour of the Friday course was lecture-based within teams, driven by and planned by students to include guest speakers on UN-SDGs. The second hour of the class was conducted via group meetings within teams, facilitated by the student project manager for each project area. Detailed technical reviews on projects also occurred within teams and industry advisors were invited to participate and critique in ways that they would not always be able to do in a large, face-to-face course.

Student Reflections

Reflections from students indicate that the earlier redesigns and the creation of the COOP were beneficial in providing access to high-quality engaged learning. These reflections included the following:

> "My worst fear was students giving up on their projects before the end of the semester.… By continuing our normal operations, just in an online setting, students remained engaged and were still able to hear from guest speakers, participate in discussions, and have directed feedback on their projects from management and advisors." (Student Program Director)

> "The [project] team was not going to be an easy turnover due to the heavy weekly lab presence, yet going online made us think further down the road with reading into more research and emerging technologies." (Student Project Manager)

> "An aspect of CEDC that I have noticed over my time in the organization is the importance of adaptability. The needs of the communities that CEDC works with change all the time, and students learn to navigate those changes while still being able to reach measurable outcomes. . . . In many ways, this simulates the situations that we will see in our internships and jobs because real projects change all of the time." (Student Project Manager)

Furthermore, students surveyed at the end of the spring 2020 semester indicated favorable responses.

> Overall, how do you think the COOP transitioned our operations? Very Well/Well: 89%; Fairly Well: 11%; Poorly/Very Poorly: 0%

Do you think that your project made good progress this semester? Yes: 87%; No: 13%

Do you think your project is feasible? Yes: 96%; No: 4%

Do you think your project matters? Yes: 100%

Engagement in the Post-COVID World

Major disruptions often drive much-needed change. Remote and virtual teaching seemed inferior prior to the COVID semester. We now realize now that a re-evaluation will be advantageous for determining which components of project-based learning belong in a face-to-face setting and which work better in a virtual environment. Although the temporary Spring 2020 disruptions limited students' ability to create lab-based or makerspace-based deliverables, students within the class and their student project leaders were forced to innovate and spend more time reflecting and planning rather than just doing.

We would also recommend that other leaders consider improving project connections to UNSDGs. Focusing on global challenges is especially advantageous now. Complex issues are multifaceted and have wide ripple effects. We look forward to continuing to "make lemonade" as we all find the new normal.

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Reflecting on Teaching Presence While Transitioning to Remote Instruction

Leyte Winfield, Shanina Sanders, and Chauntee Thrill
Spelman College
Atlanta, GA

The effort described here is informed by the Community of Inquiry (CoI) framework, which is created by the overlap of the teaching, cognitive, and social presences creates the framework. Within the social presence, students establish peer dynamics that promote productive dialog and learning. The cognitive presence characterizes a student's ability to construct meaning from engagement with their peers and instructor. The teaching presence creates an environment that facilitates learning across cognitive and social presences. Here, we reflect on our strategies for providing direct instruction and facilitating intellectual engagement at Spelman College as we transitioned to remote learning in response to the COVID-19 pandemic.

Our usual organic chemistry course is flipped. Students are required to prepare for in-person class sessions by reviewing online videos and readings and completing pre-class problems. In the classroom, students work in small groups to complete inquiry-based and problem-solving activities. Transitioning to remote learning prompted us to restructure the course in a way that both provided students the required content and allowed us to maintain a manageable workload.

Winfield: Asynchronous/Synchronous Learning

My biggest obstacle in going virtual was letting go of fears related to academic integrity and the need to control every aspect of the course. From past experiences, I understood that I could not jump headfirst into teaching remotely. I took a step back to determine which activities to replicate and which learning activities to abandon. I turned to the students to identify the activities they believed were most beneficial in the weeks before COVID-19. It was also necessary to understand their fears about transitioning to a fully online experience. Most of all, I wanted them to feel that they were co-creating the course with me.

Based on the students' input, the remote course featured asynchronous activities and a required synchronous session. The goal was to create a self-paced environment. Students met with me weekly in eight-member groups to work through problems. There were different time slots offered for the small groups, allowing students to select an option that fit their availability and time zone. I was "flexible but forceful," maintaining hard deadlines while utilizing cut-off dates for students who experienced issues. The extra time could be used at a student's discretion and allowed assignments to be submitted after the deadline without penalty. Students were allowed multiple attempts on exams with reduced credit after the first attempt. They were given the option to skip the final exam, provided they were satisfied with their course grade.

The first synchronous session did not go as planned. I anticipated that students would ask questions but was met with silence. I felt flustered during the silence, which made the hour seem longer than 60 minutes. Although students had activities we were to discuss during the synchronous session, I realized that more structure was needed to guide the time. Therefore, I used worksheets, accompanied by a 10-minute overview discussion, to structure the remaining sessions.

Sanders: Synchronous Learning

Wrapping my head around teaching online was a big lift for me. My main concern was figuring out the most fluid transition for myself and my students. I wondered how to keep the course structure similar to that prior to COVID-19 and how to give exams. Because the course was flipped, online activities were already in place, but I opted for synchronous instruction. The original class time was maintained, which was the preference of my students. The synchronous sessions, consisting of mini-lectures and problem solving, were recorded for students unable to meet during that time.

The course requirements were adjusted to reduce the number of graded activities, consolidating weekly pre-class questions and post-class assignments. However, I wanted to ensure that students continued to make progress on the coursework and did not fall behind. I designed additional assignments to offer immediate feedback and triggers to help students pace their learning. I also provided flexibility with deadlines. Like Dr. Winfield, I allowed multiple attempts on exam questions and allowed students to use their textbooks.

During the first week of remote learning, students seemed eager but had some anxiety about the transition. They were very encouraging, expressing that "this is a new experience to get through together." Attendance and energy were initially high, but they both decreased as the semester progressed. Similar to what I have observed in the in-person setting, some students go further into the materials, attend office hours, and answer questions unprompted, while others try to disappear into the background. I found it more challenging to engage with the latter group online. In the future, I will require small-group meetings throughout the course of the semester to encourage engagement, and use online forums to stimulate student questions and discussion.

Responding to Current Events

We both are engaged in a project to further develop students' science identity, ensuring they understand their role and the relevance of science in addressing the problems they see in society. During the transition, we both utilized activities to enhance students' ability to analyze and critique chemical data related to real-world issues. The activities, which include case studies and the deconstruction of research articles, focus on exploiting functional groups to synthesize drug, and explaining their efficacy.

Dr. Sanders' students analyzed selected portions of a research article pertaining to development of new opioid analgesics with reduced side effects. The discussion of opiates was a part of the course before COVID-19. The topic is also relevant to the pandemic as practitioners search for ways to address chronic pain experienced by COVID-19 patients. Questions related to stereochemistry, functional group manipulation, and isolation techniques allowed the students to connect this topic to their coursework while learning about how computational modeling can lead to structure-based optimization. For example, students were able to see how the lead compound from computational analysis was manipulated in terms of stereochemistry to improve potency towards a designated receptor and how addition of a hydroxyl group could aid in docking via hydrogen bonding.

Dr. Winfield utilized *Foundations of Organic Chemistry*. The resource features a series of case studies entitled, "Who Gives a Darn," that illustrates the application of organic chemistry concepts to understanding the development and synthesis of drugs. Throughout the semester, the case study presents students with drugs that contain a functional group currently being discussed in the course. For instance, students link the nucleophilic acyl substitution reaction to the formation of the drug Zoloft®, and the formation of hemiacetals to the metabolism of codeine.

Exam questions were used that explored the structure of drugs that are under clinical trial for the treatment of COVID-19, remdesvir and lopinavir. The original questions were created to focus on spectroscopy in the organic chemistry classroom. These were modified to ask students to (1) identify the carboxylic acid derivatives present in the molecules and (2) characterize the intermolecular forces experienced by the molecules. Students were also asked to explain the role of hydrolysis in the metabolism of the drugs.

Lessons Learned

In teaching online, it is important to tailor the course so that the activities planned are necessary for content mastery and for achieving the desired level of rigor. Faculty should be patient with themselves and their students. They should be open to refining their strategies to create a more effective course. The current crisis is an opportunity to remind students of the relevance of science in society. The course activities described that relate to current events helped students see the role of organic chemistry in addressing a health crisis. However, we recognize the emotional toll of the pandemic, and we caution against overindulgence in the topic.

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Practicing and Simulating Social Distancing

Davida Smyth and Anne Yust
Eugene Lang College of Liberal Arts at The New School
New York, NY

We are faculty in the Department of Natural Sciences and Mathematics at Eugene Lang College of Liberal Arts at The New School, a nontraditional university located in Manhattan, NY. We had planned for Anne, an applied mathematician, to be a guest instructor for a two-week modeling module in Davida's course, Evolution, Mutation, and Computation. Davida had previously introduced students to the digital evolution platform Avida-ED (https://avida-ed.msu.edu/). Anne's task was to explore modeling and simulation more generally in four 100-minute class sessions. She intended to introduce NetLogo (Wilensky, 1999), an agent-based modeling platform, and show how it could be used to explore evolution.

We completed the first week of the module before our institution moved classes online due to the COVID-19 pandemic. Anne worked with the students, in person, to create a simulation of bacteria growth in NetLogo. For the next class period, Anne adapted a book chapter we wrote, "Simulating Bacterial Growth, Competition, and Resistance with Agent-Based Models and Laboratory Experiments" (2020), to create a scaffolded tutorial for students to work up to simulating mutation and competition over the next three sessions. The students worked on the first section of this tutorial during the second class period. The risk of infection while commuting on public transportation was on our minds, and so Anne participated via Zoom while the others were in the physical classroom. The session yielded mixed results; the combination of in-person and online instruction proved to pose additional challenges. Davida was able to help troubleshoot in the classroom, but it was difficult for Anne to assist students virtually with the mathematical portions of the tutorial.

The second half of the module occurred after a two-week hiatus from classes—one week for spring break, the other for instructors to prepare for the transition to online courses—and was completely online. By this point, the coronavirus had totally absorbed the minds of our NYC-based students, so we decided to abandon our original plan and focus on simulating relevant aspects of COVID-19. We discussed this change in advance and agreed that this would still meet the stated student learning objectives: compare and contrast the functionality of AvidaEd and NetLogo; identify the components of a model and describe how models differ from simulations; describe the limitations and constraints of models when describing biological phenomena; construct simple models to examine biological phenomena. The biological phenomena considered were shifted from evolution and mutation to the spread of infectious disease.

In the first session after the break, Anne explained to the students how to model the spread of infectious disease using the classic Susceptible-Infectious-Recovered (SIR) model and discussed variants of the SIR model. Then, Anne walked the students through the creation of a basic simulation of the spread of infectious disease with NetLogo by sharing her screen via Zoom while the students followed along. Students could have the NetLogo platform open next to the shared NetLogo screen, which was ideal, since it allowed students to reproduce the actions Anne was performing.

On the last day of the revised module, we briefly discussed the concept of social distancing, of which students were already very aware. Anne designed a simulation in NetLogo (Yust, 2020) that was based on the simulations displayed in a Washington Post article by Harry Stevens (2020), along with a tutorial that would allow the students to explore the effect of social distancing on the spread of infectious disease. Anne shared the simulation and tutorial with the students via a Google Drive posted to Canvas. The tutorial was a Google Doc, where Anne instructed students to make a copy of the document, then save it to a folder located in the Google Drive. We used breakout rooms, dividing the students into groups of two or three to work on the tutorial, responding to a series of prompts that were integrated into the tutorial. We gave the students 45 minutes out of the 100-minute class period to complete the tutorial, then they returned from the breakout rooms. At the end of the tutorial, Anne had written some reflection prompts, including a question about the limitations of the model, which we discussed in detail for the remainder of the class. Students were actively engaged with the discussion, including personal anecdotes about the (lack of) social distancing they'd seen around the city.

As part of the course, students were tasked with designing an experiment that used Avida-ED to demonstrate an evolutionary concept of their choosing. One group asked to use NetLogo instead for their project. This group used the code Anne had provided and modified it to include additional elements of the built environment in the model such as buildings, cleaning regimens, and even vaccinations. The group also produced slides and a companion that could be used to educate other students in the use of their modified model. The students in the group had taken Davida's SENCERized research course, The Microbiome of Urban Spaces, and were working with her on research projects looking at the role of the built environment in the spread of antibiotic-resistant bacteria. Another student in the group had taken Anne's first-year seminar class where they used NetLogo to simulate a variety of social and physical phenomena. It was fascinating to see the students make connections to their other courses, while integrating the knowledge they had gained through their research experiences. One of the students remarked:

> "How do you design spaces around an infectious disease? . . . It's helping us understand the way that you can look at something that's affecting the whole world right now in the classroom" (The New School, 2020).

Through this adapted learning experience, we encountered social distancing on multiple levels—academically through the actual simulation and tutorial and personally through the gradual transition to distance and online learning. Though the social distancing was trying for all of us, the academic context helped students understand its importance in slowing the spread of the disease. The synchronous online class time provided an outlet for students and faculty alike to lessen the *social* distance, while maintaining the *physical* distance necessary for public health.

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Turning STEM Education Inside-Out: Teaching and Learning Inside Prisons

JO HARDIN
Pomona College

KARL HAUSHALTER
Harvey Mudd College

DARRYL YONG
Harvey Mudd College

Abstract

The Inside-Out Prison Exchange Program is an international network of teachers and learners who work to break down walls of division by facilitating dialogue across social differences. In this model, first developed by Lori Pompa at Temple University, campus-based college students (outside students) join incarcerated students (inside students) for a college course that is taught inside a correctional facility. Compared to other disciplines, STEM courses are underrepresented in the Inside-Out program. Here we discuss the unique opportunities of teaching a STEM course inside prison using the Inside-Out approach and how it differs from other models of STEM teaching in prison. Our analysis is based on the experience of three instructors from two liberal arts colleges, who taught Inside-Out courses in statistics, number theory, and biochemistry inside a medium-security state prison for men.

Introduction

For over 20 years, the Inside-Out Prison Exchange Program (https://www.insideoutcenter.org), based at Temple University, has brought campus-based college students together with incarcerated students for semester-long courses held in prisons, jails, and other correctional settings all around the world (Davis and Roswell, 2013). The Inside-Out approach to education is a collaboration between all parties involved, not one in which higher education professors and students go to a carceral organization to "help inmates" out of a sense of volunteerism or charity. The Claremont Colleges Inside-Out program at the California Rehabilitation Center (CRC), a medium-security[1] state prison for men located in Norco, CA, was originally brought to Claremont by Pitzer College (one of the Claremont Colleges). The Claremont Colleges Inside-Out program is run in part by a group of incarcerated men at CRC who are vital members of our "Think Tank."

Although hundreds of Inside-Out courses have been taught nationwide and the outcomes have been extensively studied (Inside-Out Prison Exchange Program, 2020), a very small number of the Inside-Out courses offered to date have been in the fields of mathematics or the natural sciences. In this paper, we explore some of the unique challenges and opportunities of using the Inside-Out approach for STEM classes.

We recognize that there are myriad STEM programs inside carceral institutions. They range from the nationally supported (e.g., NSF INCLUDES Alliance) to the very local (e.g., a program at CRC that allows inmates to earn an AA degree from Norco Community College). At the Claremont Colleges, a group of student volunteers goes into prisons to teach non-credit physics, chemistry, and engineering through the Prison Education Project (http://www.prisoneducationproject.org).

In contrast, here we are addressing the specific case of bringing traditional campus (outside) students into prison, not to be teachers, but to be co-learners alongside incarcerated (inside) students. The simple difference of bringing together inside and outside students (which for us included both male and female students) fundamentally changes the structure of the classroom. Without the co-learning process, both the inside and outside students miss out. As part of the Inside-Out experience, the inside students have an opportunity to learn material to which they do not necessarily have access; but more importantly, the power structure of the learning is dismantled in a setting (a STEM class) where hierarchies typically dominate the space (Martin, 2009). For the outside students, the disruption of the power structure of the STEM classroom can be enlightening. The outside students experience the depth of learning that can happen when ideas come from many different perspectives. In our experience, the impact of the Inside-Out classroom can be transformative for both groups of students, helping them to approach their learning and the world in a more humane way (Peterson, 2019).

Here we present reflections based on three separate courses (math, statistics, and biochemistry) taught by three instructors from two different liberal arts colleges. All three instructors had completed the weeklong Inside-Out Training Institute, and we were all teaching our first class in this format. Each course was a full semester, credit-bearing course for all students, both inside and outside. During the semester, the courses met once per week for up to three hours a week inside the prison. We will talk about each course individually and then integrate our thoughts to offer a synthesis and analysis.

TABLE 1. Inside-Out STEM courses described here. Inside = incarcerated students enrolled in California Rehabilitation Center's college program; Outside = campus-based students from the Claremont Colleges

Semester	Course Code	Title	Enrollment
Fall 2018	BIO/CHEM 187	HIV/AIDS: Science, Society, & Service	12 inside, 11 outside
Fall 2019	MATH 57	Thinking with Data	8 inside, 9 outside
Fall 2019	MATH 48	Introduction to Number Theory	13 inside, 4 outside

1 In California, the level of security of a prison determines the style of housing available in that facility, and people are assigned to prisons based on a complicated formula that is supposed to measure risk of misconduct. CRC is a Level II medium-security prison, meaning that the incarcerated people there live in dormitories instead of cells.

Thinking with Data (Jo Hardin)

Although Math 57 was a statistics class taught at an introductory level, it was not "Introduction to Statistics" as most university campuses conceive it. The learning goals centered around being able to critically evaluate numbers and claims based on data that are presented. The hope was for the students to realize that statistical conclusions are being made around them every day, and that to understand how those conclusions come about is a matter not only of quantitative literacy but also of a larger logical framework.

Each week, the students read from a chapter of a statistics text (Utts, 1999) along with external articles. For example, during the week when we covered sampling, the text was supplemented by articles on the sampling methods suggested by the Census Bureau as a way to improve the accuracy of the census—methods that were ultimately ruled unconstitutional by the Supreme Court, although statisticians believe the outcome of the ruling is to continue to undercount people of color and people with transitional living situations (*Department of Commerce v. U.S. House of Representatives*, 1999). During the week covering probability, we spent time discussing forensics and how different "match" probabilities (e.g., hair match, DNA match, etc.) can have very different accuracy rates.

A typical day started with an activity designed to bring us all into the space, followed up with an activity which would highlight the day's topic. For example, during the week in which we covered confidence intervals, I brought in a blow-up globe. We stood in a circle and threw the ball to one another, each time recording whether our right thumb landed on water or land. We used technical details from the week's readings to calculate a confidence interval for the proportion of the Earth that is covered in water. (Depending on the correctional facility's character, you might not choose to throw a ball around in an Inside-Out class; some facilities have strict security protocols and will not allow anything to be thrown around the classroom.)

After the topic-specific activity, we would often gather in small groups with a list of pre-written discussion questions. The thought questions were meant to help the students dig deeper into the readings and debate the topic at hand. Time and again, both the inside and outside students reported that the group discussions were their favorite part of the class. In their small groups, hesitant students were given a voice, and each student could share their understanding of the material without fear of speaking up incorrectly in front of the entire class.

Although we often ran short on time, we would always close with some kind of reflection on the material or on the day's activities. Sometimes we would go around the circle with a one-word reflection. Sometimes I would ask them to report the part of the day which they were still struggling to wrap their heads around, or, slightly nuanced, the topic which was hardest to understand in general.

After the class session each week, students were asked to write a reflection essay. The reflection essay was among the most powerful aspects of the class, as it gave the students an opportunity to spend time putting down on paper both their emotional reactions and their understanding of the statistical topics. The reflection paper had three sections: (1) observations from the class meeting—anything that stood out, (2) statistical analysis—using references from the texts, and (3) emotional reactions—feelings.

The reflections essays were not given a letter grade, yet they served the incredibly valuable purpose of connecting each and every student to both the material (statistical content) and the people in the room. Detailed instructor feedback was provided on the essays, and without the essays, especially the personal reflection part, it would have been much harder for the students to feel connected and integrated into the course.

The last three weeks of the semester were spent working on projects whose purpose was to bring the ideas from the class into a larger space. Outside visitors were invited to the closing ceremonies, but the logistics surrounding visitors' clearance was unfortunately too complicated. Instead, the students presented their projects to each other. One group did a Dear Data (http://www.dear-data.com/) assignment where they compared artistic visualizations of the data describing a week in an inside student's life with a week in an outside student's life. Another group made a chain link out of construction paper where each link detailed a study, a dataset, or an individual's story describing recidivism. A third group talked about some of the biggest misconceptions in statistical studies and how we can raise our consciousness to form valid conclusions about a study.

HIV/AIDS: Science, Society, & Service (Karl Haushalter)

Chemistry 187 explored scientific and societal perspectives on infectious disease. The course was divided into three modules focusing on plague, HIV-AIDS, and tuberculosis, with time approximately evenly divided between societal context and scientific content. The complex and multidisciplinary challenges of responding to highly stigmatized infectious diseases such as HIV-AIDS can be fertile ground for exploring the entanglement of science and society, as demonstrated by the large number of published courses that use HIV-AIDS as a focus for integrating science education and civic engagement (for example, see Fan, Conner, & Villarreal, 2014; Iimoto 2005; SENCER 2020a; SENCER 2020b).

Chemistry 187 was taught with the Inside-Out pedagogy, which emphasizes a dialogic approach with the majority of class time spent in small, mixed discussion groups (Pompa, Crabbe, & Turenne, 2018). For the Chemistry 187 content related to our societal readings, this format was a natural fit for the issues we examined. The students learned substantially from each other, especially given their differing perspectives based on life experiences related to the social determinants of health, which was an underlying theme of the course.

Implementing the Inside-Out pedagogy for the science content of Chemistry 187 was challenging for me as an instructor. Many of our chosen topics (e.g., virology) required a firm understanding of threshold concepts (e.g., the central dogma of molecular biology) in order to have an entry point into meaningful discussions (Meyer and Land, 2003). As an instructor, I felt that I could not ignore the variation in previous exposure to biology instruction, but I did not want to center upon this difference either. Thus, even though the students majoring in biology could have taught lessons on the threshold concepts, this approach would be counter to the spirit of Inside-Out in which the students are all co-learners. Ultimately, I used a hybrid approach that featured some mini-lectures that I strived to make as interactive as possible. When possible, these mini-lectures were preceded by small-group brainstorming sessions to generate motivating questions for the mini-lectures and followed by small-group applied problem-solving sessions. The Inside-Out emphasis on community building, through icebreakers, circle activities, and jointly authored ground rules, paid dividends in the smooth functioning of the small group science lessons.

If Chemistry 187 were taught as a traditional college campus-based course, the class would utilize technology (lecture slides, PyMOL, YouTube animations) for visualizing the molecular details of host-pathogen interactions. In prison, where it was not possible to routinely access this type of technology, our class had to develop other methods to help the unseeable be seen. Indeed, the absence of technology led to creative solutions. By providing the students with large-format flip chart paper and thick colored markers, I allowed them to be creative in making colorful, detailed images that were even more informative than the standard slides used in the traditional campus-based course. Several of the students had untapped artistic talent and working together with their classmates to interpret our readings, they were able as a group to communicate complex scientific ideas visually on the flip chart paper.

An important part of an Inside-Out course is the end-of-semester group project. These projects are intended to be focused specifically on intersections of the course disciplinary topic and prison, with a strong emphasis on application (Pompa, Crabbe, & Turenne, 2018, p. 55). In Chemistry 187, teams were blended, with two or three inside students and two or three outside students in each team. All students were tasked to bring their own expertise to bear on the project, the theme of which was picked by the student teams. For example, one of the student teams created educational posters about influenza vaccination. As a class, we learned from the inside students that the flu vaccine is available at the California Rehabilitation Center, but many incarcerated men do not opt to get vaccinated, possibly due to low trust in the prison health system and widespread conspiracy theories (e.g., prison officials used the flu vaccine to inject people with tracking devices). This is a missed opportunity to prevent a serious communicable disease that spreads easily in confined spaces (Sequera, Valencia, García-Basteiro, Marco, & Bayas, 2015). Working together, the inside and outside students on this team developed materials to address the common concerns of the target audience related to influenza vaccination and provide health-promoting education in the context of prison.

Other team projects included a letter to the warden proposing the adoption of harm reduction strategies (e.g. bleaching stations for sterilizing needles used for illicit tattoos or injection drug use) to reduce the spread of hepatitis C in prison; educational pamphlets about preventing sexually transmitted diseases; and an evidence-based letter to the State Prison Board about the connection between nutrition and a healthy immune system. The student projects shared in common the key feature of bringing together inside and outside students to share their unique expertise as they collaborated on a project that applied what they had learned about the science of infectious disease during the semester to an authentic issue in the living context of the inside students.

Introduction to Number Theory (Darryl Yong)

Even though I have no formal training in number theory, I chose to teach this subject because it lends itself well to exploration and rehumanizing approaches to teaching and learning mathematics (Goffney, Gutiérrez, & Boston, 2018). Requiring only some mathematics skills and ideas from high school algebra, this course started with the divisors of integers and modular arithmetic and culminated with the Rivest–Shamir–Adleman (RSA) cryptosystem, a widely used method for secure data transmission.

Of our three courses, this one was perhaps the most grounded in its disciplinary content. While I organized several class discussions around our prior experiences of learning mathematics and about contemporary mathematicians (mostly of color), about 90% of class time was spent working on carefully sequenced sets of mathematical tasks in small groups. Students shared their results communally on the board, and I occasionally convened the group to share their findings with each other. The list of tasks for each class was adjusted based on what students accomplished and found interesting in previous classes.

In "Math Instructors' Critical Reflections on Teaching in Prison," Robert Scott writes: "A math pedagogy premised upon following the rules, accepting that there is only one right answer, and relying on practice/repetition in order to habituate oneself to predetermined axioms would seem to reprise the culture of incarceration itself." How does one teach a class on a well-established field like number theory without reproducing the dehumanizing effects of prisons in the classroom?

To do this, I used a pedagogical approach based on my work delivering professional development to secondary school teachers through the Park City Mathematics Institute. In this approach, students encounter new mathematical ideas without any formal definitions or specialized notation. The mathematical tasks are designed to encourage students to look for patterns and make connections. Mathematical ideas are solidified when students give voice to them by sharing them publicly. Finally, after several exposures to similar patterns and connections, I formalized ideas by introducing their established mathematical names and notations. I followed this general approach during the entire course except for the last day of class when we used all of the machinery that we had developed to explain how the RSA cryptosystem works (Omar, 2017). So, even though students were often practicing and repeating mathematical calculations, they were in fact creating meaning for themselves and others in the classroom.

My observations of the students' progress and their written reflections lead me to believe that they truly enjoyed learning mathematics, even though some had been traumatized by previous mathematics learning experiences. Each class period seemed to fly by. Students would work almost continuously for the entire period, though there was also quite a bit of casual banter and joyful laughter around the room. It felt like a space where both inside and outside students were doing mathematics and creating meaning together. My Inside-Out experience made me wonder why I don't try to use more of this kind of rehumanizing pedagogy in my usual classes at Harvey Mudd College.

Lessons Learned

Examining the experiences of the three instructors, we find that several common themes emerge from our efforts to integrate STEM content within the Inside-Out Prison Exchange program. First, while many undergraduate STEM courses are primarily lecture-based, the Inside-Out program challenges faculty to use liberatory pedagogies (Freire, 1970). Thus, we all chose to minimize lecturing as much as possible and spend most of our class time in small group activities or whole class discussion. These forms of instruction democratize intellectual authority in the classroom and allow both inside and outside students to draw on personal funds of knowledge. An inside student wrote, "In non-Inside-Out classes I don't learn who my peers are, whereas this class was unique in the fact that we were learning from one another just as much as we were learning from our professor." Furthermore, with the inside and outside students constantly talking together and working with each other, the students discovered for themselves the many ways in which traditional college-age STEM students and incarcerated STEM students share common struggles, concerns, and motivations.

A second common theme that we encountered in our classes was how Inside-Out courses helped students uncover and confront societal expectations and stereotypes about who is competent in STEM. In our end-of-course evaluation surveys, we asked students what their biggest worry about the class was prior to starting the course. A few outside students wrote that they were concerned that the Inside-Out course wasn't going to be as rigorous as their usual courses, whereas inside students wrote that they were initially concerned about being able to "keep up" with the outside students. These concerns relate to societal stereotypes that STEM competence is innate rather than a skill to be developed and that incarcerated people and people of color are not able to access STEM. Fortunately, these surveys also revealed that students uniformly felt their Inside-Out courses to be intellectually demanding and that inside students felt successful in the class and were recognized for their contributions in class. The reason that students were able to upend their worries was because our Inside-Out courses brought together groups of people who would otherwise never get to meet each other in the context of doing rigorous, challenging STEM work together. One inside student wrote that he was surprised at the "ease [with] which people from diverse lifestyles and backgrounds can struggle with a subject, work together, and succeed."

Finally, all three of the authors chose to teach an Inside-Out course primarily because of the humanity it offered to our work. And while none of us are experts in criminal justice, we are all deeply aware that STEM is neither objective nor apolitical. When designing our courses, we specifically chose topics and approaches that would connect STEM back to the human condition, for example, discussing how disease manifests in different communities, how forensic probabilities do not represent truth, and how mathematical self-identification is different from mathematical ability. There is abundant evidence that bringing humanity into STEM can have an enormous impact on marginalized communities, and we believe that our courses are part of that trend.

Along with humanizing the course content in each of our STEM courses, the act of bringing the courses inside is a manifestation of our collective belief that STEM is not the domain of the privileged few. Instead, science and science education belong to and are in service of all people. In plain sight of each other, students of all backgrounds are able to embrace the learning of STEM content. Creating a space that allows for the tangible recognition by everyone involved that STEM is for all people is itself a highly political act.

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Dedication

This article is dedicated to the memory of David L. Ferguson, whose lifelong work in extending the joys and benefits of STEM education to underserved students continues to inspire us. David saw the potential to be a scholar in all of his students, even before they could see it in themselves. We strive to follow the example of David's pioneering work in diversity and inclusive excellence in STEM education.

Authors

Jo Hardin (*Jo.Hardin@pomona.edu*) is a professor of mathematics at Pomona College. She is a statistician by training, and her research focuses on applied and interdisciplinary projects with molecular biologists. Through the Posse Foundation, she has mentored students at Pomona College originally from Chicago, IL.

Karl Haushalter (*haushalter@hmc.edu*) is an associate professor of chemistry and biology at Harvey Mudd College. His research interests include the enzymology of DNA repair and the regulation of gene expression by small RNA. Karl works closely with the Office of Community Engagement at HMC and has led faculty development workshops to promote community-based learning.

Darryl Yong (*dyong@hmc.edu*) is a professor of mathematics, associate dean for faculty development and diversity, and mathematics clinic program director at Harvey Mudd College. He was also the founding director of the Claremont Colleges Center for Teaching and Learning. His scholarship has several foci: the retention and professional development of secondary school mathematics teachers, effective teaching practices in undergraduate STEM education, and equity, justice, and diversity in higher education.

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Preparing Preservice Teachers Using a Civic Engagement Model:

The Effect of Field Experience on Preservice Teacher Knowledge, Skills, and Attitude

DR. SARAH HAINES
Towson University

CHELSEA MCCLURE
Towson University

Abstract

Participating in a civic engagement partnership, Towson University preservice teachers deliver educational programming at the National Aquarium to students from local schools, focusing on Chesapeake Bay water quality and human impact. Teaching Environmental Awareness in Baltimore (TEAB) is designed to engage students (both preservice teachers and K–12) in environmental issue investigations relevant to the local community and promote deep, critical thinking. From a civic and socio-scientific viewpoint, our project has the following aims: (1) to focus on urban youth who may have limited personal experience with nature and/or have a limited understanding of local natural resources, (2)to assist preservice teachers in becoming confident, competent environmental educators through practical, hands-on professional development, (3) to enact a place-based environmental curriculum that meets both the instructional guidelines of local school districts and State content standards.

Introduction

A national movement, sparked by Richard Louv's (2005) treatise *Last Child in the Woods*, has catalyzed collaborations among government agencies, schools, and nonprofit and community organizations, with the goal of reconnecting children with the environment. The positive impacts of spending time in nature on a child's physical, cognitive, and social development have been well established in the literature (James, Banay, Hart, & Laden, 2015; Thompson Coon et. al., 2011; Rook, 2013). These impacts are especially crucial due the lack of public understanding in the United States of the importance and benefits of nature and the ecosystem services it provides (Duvall & Zint, 2007; Turnpenney, Russel, & Jordan, 2014).

The State of Maryland contains rich and varied natural resources that provide both tangible and aesthetic value to its residents. These natural resources provide critical ecosystem services that maintain clean air and water and provide productive land to support its residents. Despite its aesthetic and economic value, Maryland's natural resources face a multitude of long-term environmental threats. For instance, the Chesapeake Bay has been the focus of ongoing restoration efforts for more than two decades; yet, in recent years , the University of Maryland Center for Environmental Science assigned the Bay a D+ in overall health, based on six ecological indicators (University of Maryland Center for Environmental Science, 2018). Nutrient pollution from agriculture continues to be a problem in freshwater streams and rivers. Land development, especially along the shores of the Bay, continues at a rapid pace, and this land development threatens the water's-edge ecosystems along the shores. Baltimore joins other post-industrial legacy cities in an uphill battle to modernize aging infrastructure and rehabilitate local waters stressed by generations of manufacturing outflow and inadequate regulation. Even as the industry of the Inner Harbor has been replaced by a revitalized waterfront and service economy, water quality continues to suffer as storm run-off and sewage overflows raise bacteria, nutrients, and debris levels well above of healthy levels. Air quality, especially in central Maryland, ranks among the worst in the nation (Goldberg et. al., 2014). Critically evaluating local environmental problems and developing solutions is difficult and requires fundamental understanding of the interconnectedness of ecological systems and human impacts on them. The conservation, restoration, and long-term sustainability of Maryland's natural resources are dependent on future generations of citizens who can serve as environmentally literate stewards of the state's natural resources and can make informed decisions that will affect their families and their communities.

Environmental education rooted in local, place-based issues is one way to ensure that our youth have the knowledge and skills necessary to address these complex socio-scientific issues as adults (Klosterman & Sadler, 2010). Furthermore, environmental literacy is a component of overall scientific literacy (Blumenstein & Saylan, 2011) and requires the same skills as other STEM fields (Jordan, Singer, Vaughan, & Berkowitz, 2009). With the goal to create a more environmentally literate citizenry, the following initiatives have been implemented in Maryland K–12 schools over the past six years:

- Environmental literacy standards for K–12 students were adopted.
- The state began requiring that all students enrolled in public schools are to engage in a "meaningful watershed educational experience" at least once at the elementary, middle school, and high school levels (Chesapeake Bay Watershed Agreement, 2020).
- Beginning with the freshman class of 2013, all high school seniors must satisfy an environmental literacy graduation requirement (Maryland State Department of Education, 2019). To date, Maryland is the only state to mandate this requirement, although several other states have adopted and implemented environmental literacy standards.

These changes in K–12 education in Maryland Public Schools have created the need for school systems and institutions of higher education to reevaluate how they deliver instruction for both K–12 students and the preservice teachers who will eventually be teaching them. School districts need support from outside partners to provide appropriate and meaningful watershed educational experiences for all students. Additionally, there is a pressing need to provide appropriate training to preservice and inservice teachers; they must have the content knowledge and pedagogical expertise to ensure their ability to plan instruction that will align with the new environmental literacy standards and meet the requirements for the Meaningful Watershed Educational Experience (MWEE). This will enable our students to eventually meet the environmental literacy graduation requirement.

We aimed to address these needs by forming a partnership between an institution of higher education (Towson University) and an informal educational institution (National Aquarium). In this partnership, Towson University preservice teachers deliver educational programming focusing on Chesapeake Bay water quality and human impact to students from local schools. Teaching Environmental Awareness in Baltimore (TEAB) is designed to engage students (both preservice teachers and K–12) in environmental issue investigations relevant to the local community and to promote deep, critical thinking. From a civic and socio-scientific viewpoint, our project has the following aims:

1. To focus on urban youth who may have limited personal experience with nature and/or have a limited understanding of local natural resources,
2. To assist preservice teachers in becoming confident, competent environmental educators through practical, hands-on professional development,
1. To enact a place-based environmental curriculum that meets both the instructional guidelines of local school districts and State content standards.

We are also aiming to address the following more overarching civic issues through our project activities:

- The infrequency of contact between children and nature and their lack of appreciation and awareness of the local environment,
- A disproportionate lack of exposure to nature for at-risk urban youth,
- The need for well-trained teachers who can provide experiential education opportunities that foster children's affinity for nature and a stewardship ethic that is supported by knowledge.

Although our project involves several entities, and our goals stated above address more than one audience, the data presented here focus mainly on the effect of the project on preservice teachers. In particular, we wanted to answer the following questions:

Can integrating non-formal educational field experiences that focus on local environmental issues into teacher preparation programs promote enhanced preservice teacher content and pedagogical knowledge, as perceived by preservice teachers?

Can integrating non-formal educational field experiences that focus on local environmental issues into teacher preparation programs promote more positive attitudes towards teaching environmental education, and perhaps toward the environment itself?

The specific objectives of this study are as follows:

- Preservice teachers will report deepened understanding of how environmental factors affect aquatic life in the Chesapeake Bay.
- Preservice teachers will feel confident teaching environmental education topics in non-formal settings.
- Preservice teachers will demonstrate increased personal interest in environmental issues affecting their local community.
- Preservice teachers will report strengthened pedagogical content knowledge in delivering science lessons.

Program Partners

The pilot semester of our project was financially supported by a SENCER-ISE grant awarded to Towson University and the National Aquarium.

Since its opening in 1981, the National Aquarium has been a gem in the very heart of Baltimore's Inner Harbor, and generations of Maryland families have walked through its doors and shared in the wonders of the undersea world. Its mission, to inspire the conservation of the world's aquatic treasures, has motivated thousands of Marylanders to appreciate and protect the delicate habitats in their own backyards. The Aquarium educates more than 150,000 Maryland schoolchildren a year, both at the Aquarium and in the classroom. The Aquarium's conservation and education programs, coupled with the many affordable-access programs offered to Maryland residents, ensure that nearly 400,000 Marylanders are able to visit the Aquarium each year. Urban conservation is a major theme in the Aquarium's new Conservation Plan. Under this plan, the Aquarium is working to provide urban residents with the tools and skills to make changes in their communities. Because we are a coastal city, Baltimore's urban communities are becoming increasingly impacted by environmental challenges. To combat these challenges, an educated citizenry is necessary.

Towson University is recognized as Maryland's preeminent teacher education institution and as a national model for professional educator preparation. The Fisher College of Science and Mathematics (FCSM) at Towson University has a distinguished history in the preparation of STEM classroom teachers and STEM education specialists. The Fisher College prepares STEM preservice teachers to become facilitators of active and inclusive learning for diverse populations of students. FCSM faculty, who comprise a diverse community of teacher-scholars, have a wide range of strengths and specialties. Academic programs require teacher candidates to demonstrate professional knowledge, skills, and dispositions that place students at the center of active learning and emphasize higher order thinking. Through innovative educational partnerships, TU's certification programs provide teacher candidates with progressively responsible field and/or clinical experiences in a variety of settings. These rich experiences are designed to enable teacher candidates to merge theory with classroom practice and to develop and refine their knowledge of and skills in STEM teaching and learning.

At the Aquarium, preservice teachers are able to directly apply their learning from postsecondary coursework in a practical setting. As a result, they gain valuable career experience while making a significant contribution to the local community and its children. By serving as educational interns, the preservice teachers serve the needs of the local community by fostering environmental awareness among urban youth.

Methods

Research Design: Participants

Subjects in this study were elementary education preservice teachers at Towson University who were enrolled in one section of SCIE 376: Teaching Science in the Elementary School. Maximum enrollment in these sections is 18. Typically, students are 19–23 years old, and most are female. There were 16 students enrolled in the Fall 2017 pilot semester and 13 students enrolled in the Fall 2018 semester. The study utilized convenience sampling; thus, any preservice teacher enrolled in the course could participate but was not required to. Students were recruited regardless of age, sex, or ethnicity. The research design and participant recruitment methods were approved by the university institutional review board.

Research Design: Location

All activities were conducted at the National Aquarium in Baltimore, Maryland. The location of the National Aquarium was well suited for our purposes for two reasons. First, the Aquarium is located on a major tributary of the Chesapeake Bay, making it a perfect venue for investigating the socio-scientific issues surrounding water quality and watersheds. Second, the Aquarium is located in the same community where our target school-age population lives, allowing us to emphasize place-based educational strategies.

Research Design: Task/Preservice Teacher Content

The field study component that is required of a MWEE is often difficult for Baltimore City Schools to implement due to a lack of safe study sites within the local area. The National Aquarium is a logical partner for them, as it is located in the same neighborhood as the schools and students we are aiming to reach, and there are many accessible study sites on the aquarium property where students can safely access the water and examine human impact. The "What Lives in the Harbor" program is designed to meet the Chesapeake Bay Agreement requirements for an MWEE and is aligned with the Baltimore City Public Schools sixth-grade curriculum. MWEEs are learner-centered experiences that focus on investigations into local environmental issues that lead to informed action and civic engagement. Educators play an important role in presenting unbiased information and assisting students with their research and exploration. In our case, the field experiences take place at the National Aquarium, entirely outdoors. Students begin their visit to the Aquarium's waterfront campus with a brief discussion about their local Baltimore Harbor watershed and its place within the larger Chesapeake Bay. Students then rotate through three stations where they take water quality readings. At the request of City Schools the Aquarium uses Vernier equipment, which is the same equipment used in high schools. Each station is led by two preservice teachers and lasts approximately 25 minutes. At each station, students collect quantitative data that will help them determine which organisms on their organisms cards would be able to survive in the harbor, based on the data they have collected. All data are recorded on paper data sheets, and also on portable electronic devices, which save the data for reference later; the data are also sent to the classroom teacher for later use in synthesis and conclusion activities that take place in the classroom. A brief description of each station appears below.

- **Plankton & Turbidity:** Turbidity is defined and the consequences of low or high turbidity are discussed. Human impact on turbidity is emphasized as well as the impacts of high turbidity, such as decrease in the amount of light available for photosynthesis and increased water temperature. Turbidity is measured with a Secchi disc. Students assess phytoplankton living in the harbor using handheld microscopes and observe water color to determine the species of phytoplankton present. The observation and discussion of plankton in the water emphasizes the key role that plankton play as a primary food source for the harbor's food web.
- **Dissolved Oxygen & Salinity:** Dissolved oxygen and salinity are measured with Vernier probes. Dissolved oxygen and salinity readings are taken both at the surface and closer to the harbor bottom. Human impact on these parameters is discussed, as well as what the measurements mean for the organisms living in the watershed. Emphasis is placed on the impact that low dissolved oxygen levels have on the ability of aquatic organisms to survive in certain water systems and the impact of salinity changes as a stressor for marine ecosystems.
- **Temperature and pH**: Temperature is measured with a digital thermometer and pH is measured using pH strips. Common household items (bleach, milk, orange juice) are used to relate the pH scale to the students more effectively. Emphasis is placed on the influence of temperature and pH on the chemical and biological reactions in marine ecosystems.

After completing all of the stations, students analyze the data they have collected to determine which organisms would be able to live in the Baltimore harbor, and are asked to support their conclusions with evidence from the data. To test their hypotheses, students survey and catalog what they find in bio-hut cages suspended off the Aquarium piers using the iNaturalist app on an iPad. The bio-hut is a double cage system where one side is filled with oyster shells that attract rapid colonization by microorganisms. The oysters are seeded with spat (juvenile oysters) that grow and serve as biological filters by filter feeding and removing algae from harbor water. Mussels and barnacles that attach themselves to and grow on the oyster shells act as living filters in these urban waters. The outer cage is empty and provides only shelter, offering a predator-free zone for juvenile native fish. The double cage system of the bio-huts restores some of the ecological function once provided by the wetlands historically found in the area. The group discusses whether their predictions were correct and why or why not. They also discuss what water quality parameters seem to be the most important to biodiversity. Finally, preservice teachers have the students take inventory and count the living spat (oyster larva) on the oyster shells inside the bio-hut cages. These data are provided to the Aquarium's Field Conservation Department and contribute to one of the Aquarium's broad conservation goals. At the end of each school year, these spat will be added to the Aquarium's recently created oyster reef, which provides a unique habitat to the urban wildlife of the Baltimore Harbor. This onsite action project will help inspire students to plan their own action projects, as they learn about how the Aquarium's oyster reef, floating wetlands, and bio-huts are creating natural ecosystems that support the diverse life in the harbor. Following their field experience, students complete an action project at their schools. During the pilot, students identified one water quality parameter that is negatively affecting organisms in the harbor and then worked in groups to brainstorm issues in their neighborhood that could impact water quality and aquatic species in the harbor. Students selected one issue and suggested an action they or others in their neighborhood could take to positively change these conditions. From this exercise, pilot schools conducted several different action projects, such as discussing and designing a small garden on the school's property in the following school year; creating posters to promote improving water quality and reducing waste; writing letters to the principal and elected officials about the importance of the bay; and pledging to reduce, reuse, and recycle 10% more over summer break.

Data Collection

Survey Instrument: STEBI (Science Teacher Efficacy Belief Instrument)

The identification of various methods that can help to develop self-efficacy is becoming an increasingly important aspect of science education research and the professional development of teachers (Ginns, 1996). The STEBI was used to measure science teaching self-efficacy and outcome expectancy in preservice teachers. Since our subjects are preservice teachers, we used the STEBI-B, which is designed for this audience (Riggs & Enochs, 1990). The STEBI-B was chosen as an instrument in this study because it has been commonly used in science education research studies and because studies have found the survey instrument to have high validity and reliability (Bleicher, 2004; Bleicher & Lindgren, 2005; Settlage, 2000; Schoon & Boone, 1998). The STEBI-B consists of 23 Likert scale response items and is broken up into two subscales, personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). The subscale personal science teaching efficacy measures the participant's belief in the ability to teach the subject of science effectively (Deeham, Danaia, & McKinnon, 2017). Deeham et al. also describe the outcome expectancy subscale as a measure of the participants' broad views of science teaching related to why students perform as they do. The items for the two subscales are randomly placed throughout the survey. A paired t-test was used to determine any significant difference in the pre and post survey answers.

Survey Instrument: Environmental Education Attitudes Assessment

To assess preservice teacher attitudes and beliefs toward teaching science, specifically environmental education, an analogy was administered pre/post. Participants were asked to complete the analogy, "Teaching environmental education is like ______." They were then asked to accompany their answer with a drawing that illustrated their thoughts. The analogies that the preservice students create and explain helps to capture their attitudes towards teaching, thereby giving us insight into their teaching self-efficacy (Hanson, 2018). Data collected were coded based on the categories described in Table 1 .

After coding the data from the science teaching analogy, the analogy results were linked to the STEBI scores, to give insight into the preservice teachers' teaching self-efficacy and their attitudes towards environmental education.

Survey Instrument: SALG (Student Assessment of Learning Goals)

The SENCER SALG was administered pre/post and was used as an evaluation tool to gather learning-focused feedback from students. The SALG has students assess and report on their own learning and on the degree to which certain aspects of the course have contributed to that learning. The SALG instrument may be one of many assessment practices that can assist in gathering feedback for both teaching and learning assessment (Scholl & Olsen, 2014).

Weekly Reflections

Weekly reflections serve as an outlet for students to self-report their current attitudes towards environmental education and their assessment of their teaching. Included with each open reflection assignment is a required question for students to answer: What is your current attitude towards teaching environmental education? Have there been any changes since last week? Any positive/negative experiences?

Students completed six weekly reflections throughout the semester, and these weekly reflections were analyzed through open coding techniques using NVivo software. Interrater reliability was established through the use of two different coders to develop codes and observe trends

TABLE 1. Coding Categories for Environmental Education Attitudes Assessment

Category	Definition
Negative	Very clear negative perceptions
Struggle	Process implied with negative connotations
Uncertainty	Feeling uncertain
Indifferent	Neither positive nor negative is implied
Good with one negative caveat	Statement mainly positive with one exception (word or phrase)
Journey	Implies a struggle yet a positive or surprising outcome
Positive	Very clear positive perceptions

in the data. Three weeks out of the seven were selected using a random numbers calculator, then those weeks were coded separately by both individuals. From these three weeks, larger codes were developed: Negative Attitude, Positive Attitude, Self-Efficacy, and Classroom Management. The weekly reflections gave insight into the attitudes and self-efficacy of the students through self-reporting information.

Results

Survey Instrument: STEBI (Science Teacher Efficacy Belief Instrument)

Attitude outcomes were measured through pre/post data taken from the STEBI, which was administered to all Towson University students enrolled in the course. Paired t-test results show that the experiences at the Aquarium led to an increase in both science teaching self-efficacy ($p=.003$) and teaching outcome expectancy ($p=.031$). See Figure 1 for individual pre and post STEBI scores.

Individual questions were analyzed to determine areas of largest growth in self-efficacy. The question showing the largest gains was "I know the steps necessary to teach science effectively"; the average pre assessment score was 36 while the post assessment average score grew 14 points to an average of 50 points. Another survey question that showed large gains was "I wonder if I will have the necessary skills to teach science"; the average pre-assessment score was 34 and the post assessment average was 47. This increase of 13 points suggests that the preservice teachers were not wondering whether they would have the necessary skills to teach science as much as they did before the field experience. These individual STEBI question results are meaningful because they suggest that the preservice teachers were feeling more capable of teaching science effectively after this non-formal educational field experience.

FIGURE 1. STEBI Pre and Post Assessment Scores

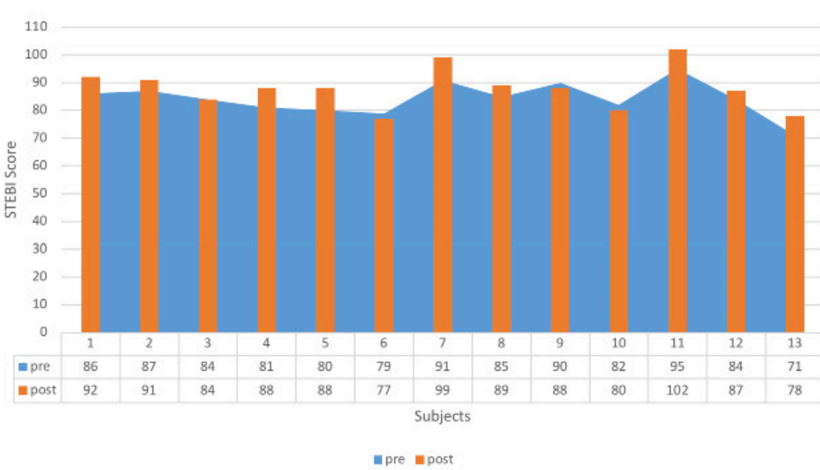


TABLE 2. Results of Preservice Teacher Coding per Coding Classification

Preservice Teacher	Pre EEAA	Post EEAA
1	Negative	Positive
2	Struggle	Good with one negative caveat
3	Positive	Positive
4	Struggle	Negative
5	Indifferent	Journey
6	Journey	Indifferent
7	Negative	Positive
8	Struggle	Journey
9	Struggle	Journey
10	Struggle	Positive
11	Negative	Journey
12	Uncertain	Uncertain
13	Uncertain	Positive

Survey Instrument: EEAA (Environmental Education Attitudes Assessment).

The results of the pre EEAA show that most of the preservice teachers' attitudes towards teaching environmental education were coded as negative or a struggle (61.5%). After the field experience, we saw a shift in the responses, as only 8% were coded as negative or struggle. Instead of a predominately struggle or negative attitude in the preservice teachers in the pre-EEAA (61.5%), we saw predominately journey and positive attitudes in the post EEAA (69%). The largest area of growth was in the positive category; only one preservice teacher was coded as positive in the pre EEAA, but in the post-EEAA there were five preservice teachers whose responses were coded "positive." Samples of each coding description appear in Table 2 above. See Figures 2 and 3 for results by coding category.

Survey Instrument: STEBI + EEAA

Linking the results

Table 3 illustrates the linkages between each participant's pre/post STEBI score and pre/

FIGURE 2. Individual Preservice Teacher EEAA Codings in Pre/Post Test

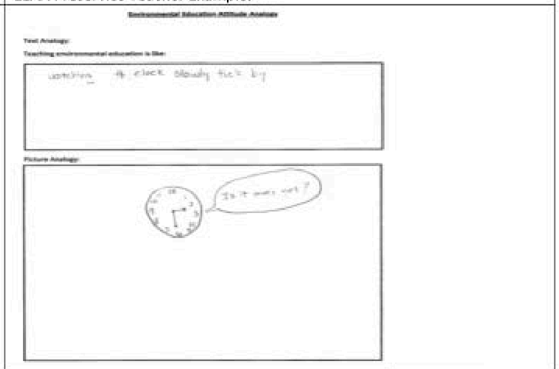
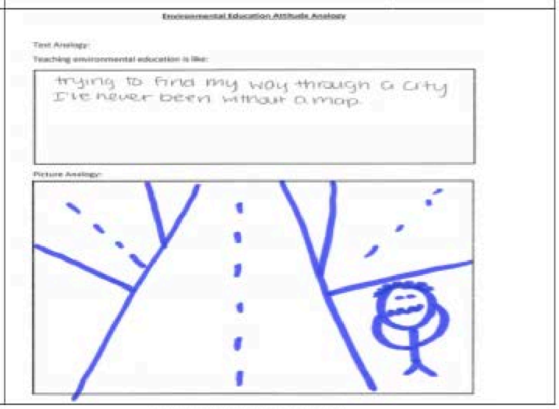
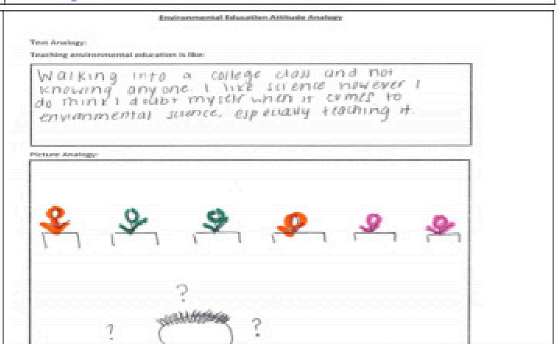
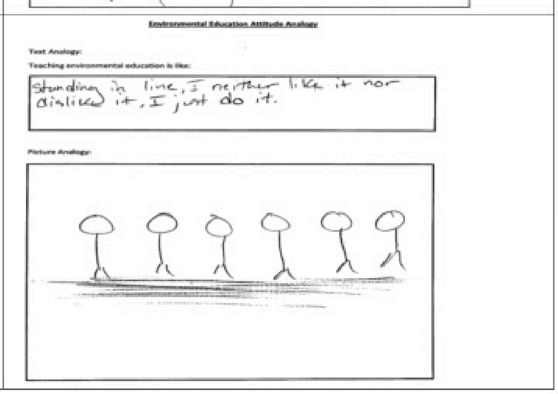
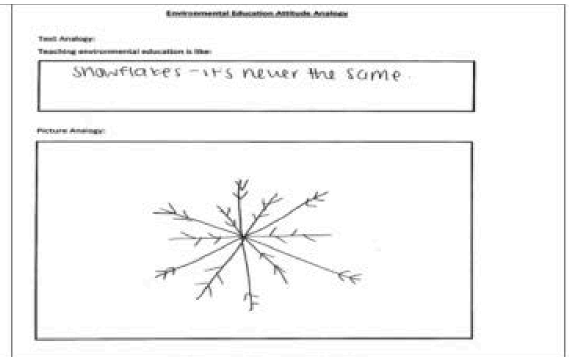
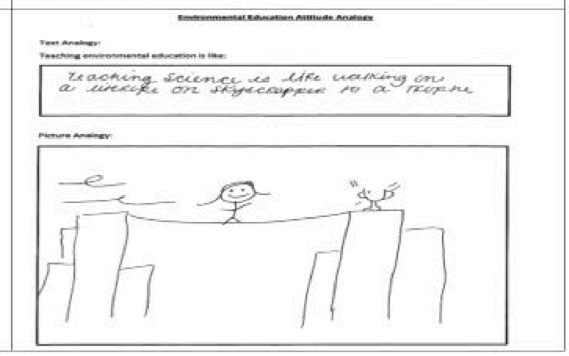
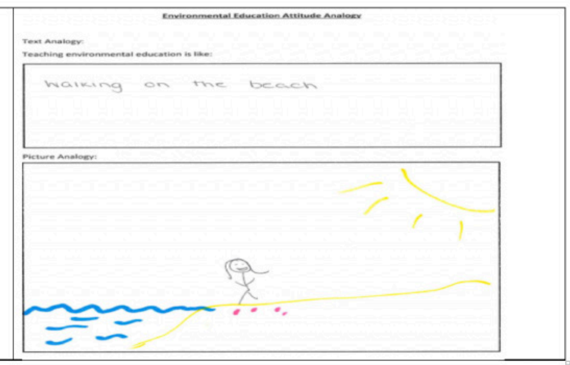
Coding	EEAA Preservice Teacher Example:
Negative	
Struggle	
Uncertainty	
Indifferent	
Good with one negative caveat	
Journey	
Positive	

FIGURE 3. EEAA Pre to Post Coding

post EEAA. Of the 13 preservice teachers who were administered the STEBI and EEAA, seven subjects (54%) demonstrated growth in both self-efficacy and in attitudes towards environmental education from pre to post. Five students (38%) demonstrated growth in one area but not the other and only one student (8%) demonstrated a decrease in both areas. Overall, there were nine out of 13 students who demonstrated growth in self-efficacy and nine out of 13 students whose attitudes towards environmental education became more positive over the course of the study.

Weekly reflections

Qualitative data collected through analysis of weekly reflections support the findings presented from the SALG that personal interest in the civic issues being studied did increase among participants. These data show that overall students became more interested in socio-scientific issues and watershed issues in particular as a result of participating in this course. A few students' comments that were written in reflections at the conclusion of the course appear below.

> *The journey has opened my eyes on topics that are related to and inside of the subject environmental science, and that I am certainly more comfortable handling and teaching the subject than I was prior to this experience.*

> *I learned how to be respectful towards the environment. It is important to teach this quality to kids at a young age.*

Students also felt that they gained skills that would help them be more effective teachers in the classroom. It was evident to us through their written lesson planning and through teaching observations that their delivery methods improved over the course of the semester, but students also reported feeling more confident in teaching science content to children.

> *Seeing how much students were enjoying and engaged in the program, I can only be reassured that environmental education is a powerful and important element to elementary education.*

> *The biggest change I have found is in my confidence level. My self-efficacy for teaching science has increased 100 percent. I feel like I know the content a lot better so I can teach my students without feeling unsure of the topics.*

> *As a teacher of science, I am growing more confident in this content and I hope to apply this knowledge to my future work.*

The NVivo coded data reveal many fluctuations in preservice teacher attitudes throughout the study. In the

TABLE 3. Individual EEAA and STEBI Pre/Post Linked Results

Subject	Pre STEBI	Post STEBI	Change (+,0,-)	Pre EEAA	Post EEAA	Change (+,0,-)
1	86	92	+	Negative	Positive	+
2	87	91	+	Indifferent	Journey	+
3	84	84	0	Uncertainty	Positive	+
4	81	88	+	Struggle	Journey	+
5	80	88	+	Struggle	Journey	+
6	79	77	-	Negative	Positive	+
7	91	99	+	Uncertain	Uncertain	0
8	85	89	+	Struggle	Negative	-
9	90	88	-	Journey	Indifferent	-
10	82	80	-	Struggle	Journey	+
11	95	102	+	Positive	Positive	0
12	84	87	+	Negative	Journey	+
13	71	78	+	Struggle	Positive	+

FIGURE 4. Attitude Coding for Weekly Reflections

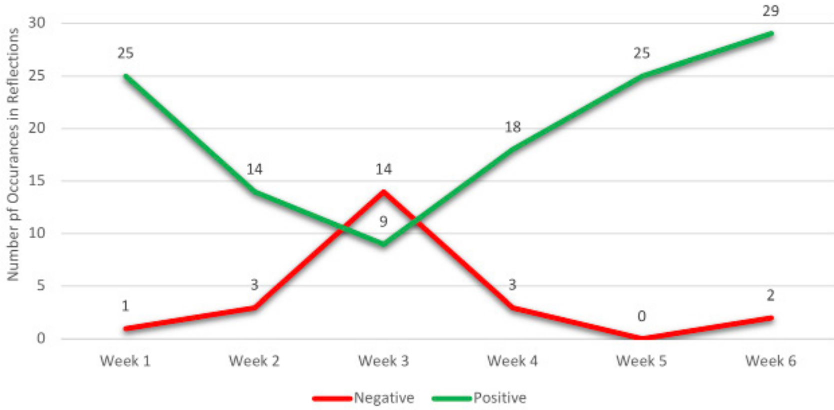
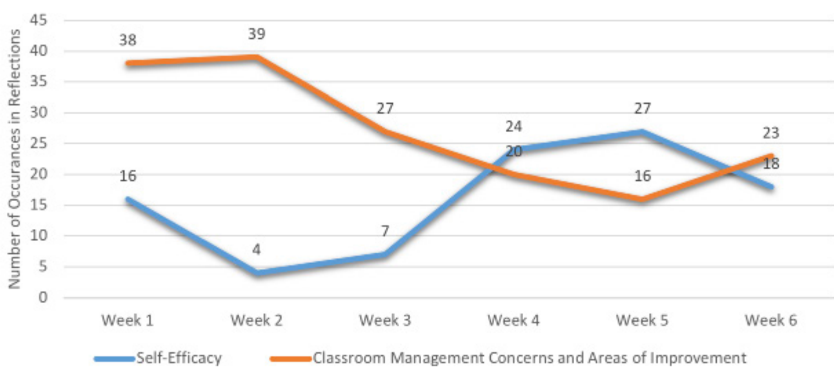


FIGURE 5. Self-Efficacy vs. Classroom Management Codes by Week



final week, there were fewer than three negative attitude codes and more than 28 occurrences of positive attitude codes. In general, positive codes tended to increase as the study progressed, and negative codes decreased after a spike in Week 3. Even though changing weekly factors at the field site, which will be noted in the Discussion section, seemed to affect preservice teacher attitude, overall there were more occurrences of positive attitudes in the last half of the field experience than in the first half (see Figure 4).

Some student responses from midway through the course that displayed these positive attitudes appear below.

I believe that my attitude is more positive now because I feel like I am learning a lot about the science content, as well as flexibility, time management, and patience, which are essential teaching skills.

My attitude towards environmental education is at a semester-high as of right now. I have always seen the value in developing a sense of environmental awareness and responsibility in the students. It is definitely fun to work with students who come into our stations with open minds and positive attitudes. It is interesting to hear about what they know, and how they connect/relate that to the information at each station.

Along with attitudes, we analyzed weekly reflections for changes in self-efficacy and classroom management concerns/areas of improvement. Classroom management concerns and areas of improvement codes decreased from 38 in Week 1 to 23 occurrences in Week 6 (see Figure 5). Self-efficacy codes were more variable. The reflections for Weeks 4, 5, and 6 contained more self-efficacy codes than Weeks 1, 2, and 3. Possible reasons for these variations are discussed below.

Survey Instrument: SALG

Personal interest data through SALG

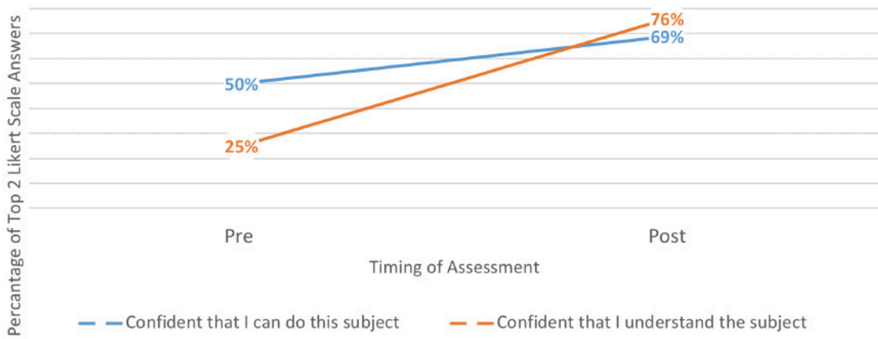
The SALG data show that students' personal interest in civic issues increased over the course of the study. Additionally, students became more interested in watershed issues and tended to regard environmental education as more important in the post test.

A few student comments taken from the post SALG survey appear below.

At the beginning of the semester, I had no idea what factors could affect water quality. Now, because of this internship, I know much more about turbidity, salinity, watersheds, conservation, etc. that I can take with me in my future.

I have gained many skills to help me teach science. I am much more interactive and believe science should be taught through experience after taking this class.

FIGURE 6. Self-Efficacy in Environmental Education: SALG Data



My confidence gained by this class will be taken with me throughout the rest of my teaching career.

The biggest change I have found is in my confidence level. My self-efficacy for teaching science has increased 100 percent. I feel like I know the content a lot better so I can teach my students without feeling unsure of the topics.

The content within environmental education is definitely something I will carry with me into my other classes, especially other science courses because it is super relevant. It is something I also hope to promote within my personal life among family and friends.

The quantitative data support these qualitative comments. For example, pre assessment data show that only 25% of students scored themselves a four or five on the Likert scale for understanding the concept of a watershed, but in the post test, this increased to 81% of students. When asked whether they understood the impact of human activities on water quality, 56% of students rated themselves as 4 or 5 on the pre test, while this increased to 81% on the post test.

The post SALG data reveal that student self-efficacy in teaching the subject of science and environmental education also increased. Students mentioned different aspects of growth; for example, they reported that their feelings of confidence and self-efficacy had increased and that they had overcome their fear of teaching science (see Figure 6). A few student comments taken from reflections at the conclusion of the course appear below.

I was afraid of teaching science prior to this experience, but I have since gained confidence.

The SALG data indicate that the largest growth areas in socio-scientific issues were in development of knowledge of the watershed and how human activities can affect water quality. These areas grew by over 20%, showing that these students have developed a deeper understanding and connection with the environment and how they as individual community members impact that environment. Confidence about understanding of environmental education, self-efficacy in being able to teach environmental education, and the ability to develop lesson plans in this area were individual questions that reflected growth from pre to post. See Table 4 for a summary of responses pre/post.

Discussion

Impacts on Preservice Teachers

The STEBI data demonstrate an increase in self-efficacy in the preservice teachers at the end of the non-formal education experience. The item of largest growth on the survey was "knowing the steps necessary to teach science

TABLE 4. Sample SALG Questions Demonstrating the Largest Gains

Number	Question	PRE: Percentage of a lot/great deal answers	POST: Percentage of good/great gain	Difference
1.	How human activities can affect water quality	56%	81%	+25
2.	How studying this subject helps people address real world issues such as water quality and habitat conservation	69%	81%	+12
3.	Confident that I can teach this subject	50%	69%	+19
4.	Confident that I understand the subject	25%	76%	+51
5.	The concept of a watershed	25%	81%	+56
6.	Writing lesson plans in discipline-appropriate style and format	31%	69%	+38

effectively," showing us that the preservice teachers have greater confidence in their ability to teach science effectively after the non-formal education experience. Raising self-efficacy levels in preservice teachers is essential; research has found that individuals who have a low sense of efficacy for accomplishing a certain task may avoid it (Schunk, 1991). Having high self-efficacy will help to ensure that the preservice teachers do not avoid teaching of environmental education, but instead feel confident enough in their abilities to be effective, capable, and enthusiastic environmental educators in their future classrooms.

The EEAA data enable us to observe a shift in attitudes in our subjects as the study progressed. These enhanced attitudes towards environmental education have an impact on their effectiveness as teachers (Ozdemir, Aydin, & Akar-Vural, 2009). If teachers do not have positive attitudes toward the topic of environmental education, then little instruction in this area will be given in the classroom (Ham, 2010). Thus, the impact of this educational experience on the promotion of positive attitudes towards environmental education in preservice teachers is meaningful for the implementation of effective EE.

Our data suggest that the more confident and competent these students felt in teaching environmental education, the more positive their attitudes became. Again, promoting both these factors is important, because when teachers perceive their ability to perform the process of teaching science to be low, their resulting dislike of teaching the subject of science translates into the avoidance of teaching science (Koballa & Crawley, 1985).

The weekly preservice teacher reflections revealed many fluctuations from positive to negative and vice versa in preservice teacher attitudes throughout the six weeks of the study. One factor that influenced these fluctuations was the school group who visited the Aquarium each week. The university students taught a different set of students from a different school each week; therefore each group of City school students was unique in level of preparedness for the trip and in background content knowledge pertaining to the trip. If the school group attending the program was well prepared and ready to participate, the preservice teachers tended to have more positive attitudes. If the school group was less prepared—for example, if the students did not seem to have much prior knowledge on the purpose of the program and the science behind it—then the preservice teachers tended to have more negative attitudes. Weather was another factor that affected the preservice teachers' assessment of how well a given day went. (The educational experience is based outdoors, and the weather naturally varied from week to week.) We are able to relate these factors to certain spikes and dips in attitudes and self-efficacy throughout the six weeks. In Week 3 we saw the most notable affect from these factors: there was a dip in positive attitude and a spike in negative attitudes, which we attribute to the weather. That week it was cold and rainy, and preservice teachers and Baltimore City students therefore complained about the weather throughout the outdoor experience. This factor affected the timing of the activities, since the schedule was adjusted because of the weather; it also affected the data collection, because student data collection papers were getting wet, and had a negative effect on student behavior, as complaints ran high. The day was definitely a challenge for the preservice teachers. We consider these conditions responsible for a dip in positive attitude by five code occurrences and a spike in negative attitude by 11 codes compared to the week before.

An opposite trend was observed in Week 5. During the programming for this week, we had several politicians and local dignitaries from Baltimore and the surrounding area observing the "What Lives in the Harbor" program. There was a news media presence there as well, and some of our students were interviewed. Many of the politicians spoke of the "good things" the Aquarium and the preservice teachers were doing. They also mentioned the positive impact the program was having on the community. Coding for Week 5 revealed the lowest level of codes for negative attitudes towards environmental education, with zero instances of negative attitudes. It appears that the university students were feeling as if they were making an impact and doing something important for their local community. It also created an increase in positive attitude codes. The students seemed to be affected by this experience and the positive feedback they received from persons not directly associated with the project. Examples from Week 5 student reflections follow.

> *My attitude towards environmental education has remained positive throughout this week. It was nice to have our efforts at the aquarium validated through the speakers during the press day. I was also*

interested to learn that this project is important not only on a state level but on a national level.

This also benefits me as a teacher of environmental education as I was congratulated on teaching the science well from an outside party's perspective. To me, this has the same effect as a parent saying I did well because while they may not understand and therefore won't focus on the teaching aspect of it, they feel that I conveyed the information well and that means a lot to me.

Impacts on Baltimore City Students

The "What Lives in the Harbor?" program not only has an impact on the preservice teachers, but it is hoped that the program will also positively impact the Baltimore City school students. While the Baltimore City Schools students were not the focus of this study, the school system has stated that the goal of the program is to reach 3,600 students annually by the year 2021 and increase their (1) knowledge of watershed concepts, (2) positive attitudes towards watersheds, (3) inquiry and stewardship skills, and (4) aspirations to protect watersheds. Measurement of progress towards these goals will be conducted by independent program evaluators. The "What Lives in the Harbor?" program plans to scale up to 67 schools by 2021, systematically adding 16–25 schools per year. As shown in Table 5, the Aquarium will use a tiered approach to serve more schools, teachers, and university interns each year over three years.

Conclusion

We believe it is essential to provide appropriate training to preservice teachers so that they have the content knowledge, self-efficacy, and attitudes to plan and facilitate instruction that will align with the new environmental literacy standards and create more environmentally literate students. We consider our project successful in view of the following accomplishments:

- Preservice teachers met the goals we had for the project and had mostly positive things to say about their experience.
- University students and faculty worked effectively with Aquarium staff to deliver quality watershed education programs to Baltimore City Public Schools students.
- A positive shift in attitude regarding environmental education was observed in the preservice teachers.
- Preservice teachers reported a deeper understanding of the environmental issues affecting aquatic life and water quality in the Chesapeake Bay.
- Preservice teachers felt more confident teaching environmental education topics in non-formal settings.
- Preservice teachers reported strengthened pedagogical content knowledge in delivering science lessons.

From a socio-scientific viewpoint, we believe that Teaching Environmental Awareness in Baltimore (TEAB) did engage students (both preservice teachers and K–12) in environmental issue investigations relevant to the local community and promoted deep, critical thinking. Our initial aims, listed below, were well addressed throughout the project.

1. To focus on urban youth who may have limited personal experiences with nature and/or have a limited understanding of local natural resources,
2. To assist preservice teachers in becoming confident, competent environmental educators through practical, hands-on professional development,

TABLE 5. The Aquarium's Tiered Approach for Systemic Implementation by 2021

Year	# of New Schools	Total # of Schools	Total # of Students	# of New Teachers Trained	# of Internships
2017-18 (pilot)		10	575	10	16
2018-19	25	35	1,880	25	64
2019-20	16	51	2,817	18	96
2020-21	16	67	3,600	18	128

Note: The 2017-2018 pilot is included to show how the Aquarium will ramp up the project from its current stage to full implementation in the subsequent three years

1. To enact a place-based environmental curriculum that meets both the instructional guidelines of local school districts and State content standards.

We were also able to address the following more overarching civic issues through our project activities:

- Increasing the frequency of contact between children and nature and fostering appreciation and awareness of the local environment,
- A disproportionate lack of exposure to nature for at-risk urban youth,
- The need for well-trained teachers who can provide experiential education opportunities that foster children's affinity for nature and a stewardship ethic that is supported by knowledge.

Through the STEBI, EEAA, weekly reflections and the SALG we were able to answer our main research questions:

1. Integrating non-formal educational field experiences that focus on local environmental issues into teacher preparation can promote better preservice teacher content and pedagogical knowledge in the majority of preservice teachers.

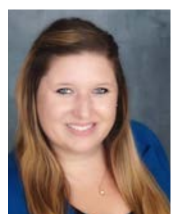
This conclusion was supported by self-reported data from preservice teachers through the SALG assessment data as well as through the weekly reflections coding data and STEBI. The preservice teachers reported having a stronger content background and more pedagogical knowledge than they did at the beginning of the field experience.

2. Integrating non-formal educational field experiences that focus on local environmental issues into teacher preparation programs can promote more positive attitudes towards teaching environmental education.

This conclusion is supported by the EEAA results and the weekly reflections coding data.

Due to the increased attention and focus on EE in K–12 schools and the need for effective EE teachers, implementing methods that enhance teaching self-efficacy and attitudes in the field of environmental education at the preservice stage of teaching could be of value to educators, preservice teachers, and the communities that they will eventually serve. We envision future iterations of this partnership that will include evaluating the preservice teachers who deliver EE programming using the same types of evaluation tools we might use in a formal education setting. For example, lesson planning and delivery could be evaluated using instruments such as the Reformed Teaching Observation Protocol (RTOP) (Sawada et al., 2000) or the Danielson framework (Danielson, 1996). We are also considering integrating Teacher Performance Assessment (edTPA) rubrics (Ledwell & Oyler, 2016) into the course in order to provide a more robust data set of preservice teacher progress. Much as an estuary is a transition zone between freshwater habitats and the ocean, teacher preparation is a transition zone for development between preservice and inservice teaching. Having varied experiences flow into this preservice "estuary" can help to increase self-efficacy, create positive attitudes toward teaching, and enhance content knowledge. All of these factors can aid educators in preparing students to become effective future environmental educators.

About the Authors



Chelsea McClure is a professor of biology and science education at Towson University. Her research interests lie in the areas of preservice teacher education and environmental education.

Sarah Haines is a professor of biology and science education at Towson University. Her research interests lie in the areas of environmental and nonformal education and their effects on student achievement. She integrates the SENCER ideals into most of her courses at TU.

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National Summer Transportation Institute: Increasing Career Awareness in Civil Engineering for Underserved High School Students

MELANIE L. VILLATORO, P.E.
NYC College of Technology, CUNY

JANET LIOU-MARK, PH.D.
NYC College of Technology, CUNY

Abstract

Our nation needs to increase the number of students pursuing degrees in the fields of Science, Technology, Engineering, and Mathematics (STEM) and those leading to transportation-related careers. In order to meet the demand for qualified graduates in transportation, it is necessary to diversify the pool of students entering college with an interest in these fields. The National Summer Transportation Institute (NSTI) is an educational initiative developed by the Federal Highway Administration (FHWA) and Department of Transportation (DOT). The NSTI at City Tech was designed to increase awareness of transportation-related careers among New York City high school students. The structure of City Tech's NSTI includes lectures, field trips, projects, and laboratory activities that promote the growth of each participant and strengthen their academic and social skills. This NSTI program provides a model for broadening participation in STEM and building America's STEM workforce.

Need to Increase Underrepresented Minorities in Civil Engineering

In order to remain competitive in a world of advancing technology, the United States needs to build a workforce with knowledge and skills in the fields of Science, Technology, Engineering, and Mathematics (STEM). According to the U.S. Bureau of Labor Statistics, the projected number of STEM jobs was expected to grow 18.7% during the 2010–2020 period (Fayer, Lacey, & Watson, 2017). As the country's economy and demographics change, it is important to increase the participation of underrepresented minority groups in STEM, including women (Gilliam, Jagoda, Hill, & Bouris, 2016; Briggs, 2016). Given more opportunities to develop their capabilities in STEM, this untapped population can help to fill the critical STEM workforce gap (Science Pioneers, 2017; U.S. Department of Commerce, 2011).

The U.S. Bureau of Labor and Statistics (2020) reports that the employment of civil engineers is projected to grow 6% from 2018 to 2028, an average rate faster than all other occupations. As the current U.S. infrastructure grows obsolete, civil engineers will be needed to manage projects that rebuild, repair, and upgrade bridges, roads, levees, dams, airports, buildings, and other structures. Because of the urgency to increase the civil engineering workforce, the Federal Highway Administration Office of Civil Rights (HCR) encourages academic outreaches to target groups who are underrepresented in the transportation workforce. Females, economically disadvantaged students, and students with disabilities have been identified as underrepresented minorities in STEM (NSTIP, 2012). Based on the 2010 census report, the population of the United States is about 49.2% male and 50.8% female (Howden & Meyer, 2011). But although women make up half of the college student population and the general workforce, they account for only about one fifth of all bachelor's degrees conferred in engineering in 2016 (National Center for Science and Engineering Statistics, 2017; Yoder, 2016) and a quarter of the STEM workforce (Landivar, 2013). The statistics become more dismal for minority women. In 2012, only 3.1% of bachelor's degrees in engineering were awarded to minority women (National Science Board, 2016). Specific to the civil engineering workforce, the Bureau of Labor Statistics in its *Labor Force Statistics from the Current Population Survey* (2016) states that a tenth of the jobs were held by women. Only 3.6% of the civil engineering positions were held by African Americans, 10.4% by Hispanics, and 7.7% by Asian Americans. While the population trends show that minorities will become the majority, the STEM workforce statistics clearly does not proportionally reflect this trend, particularly in civil engineering. Therefore, it is imperative that more programs be developed to promote the awareness of civil engineering occupations and to increase the participation of minorities and women in these fields.

Benefits of Exposure to STEM at the K-12 level

Many studies have shown a correlation between STEM exposure at the K–12 level and a student's interest in pursuing a STEM degree (Chiappinelli et al, 2016; Lomax, 2015; Means, Wang, Young, Peters, & Lynch, 2016; Naizer, Hawthorne, & Henley, 2014.) While the majority of American youth are exposed to STEM content in high school settings, out-of-school programming may be particularly important for sparking an interest in the STEM disciplines (Gilliam et al., 2016). Programs that engage high school students in unique STEM experiences will likely continue to play a profound role in recruiting and retaining bright young minds in the increasingly important STEM fields. Summer camps and experiences are especially important for students in urban and low-income areas, where underfunded science curricula and limited access to role models and mentors in STEM are common (Phelan, Harding, & Harper-Leatherman, 2017). Moreover, post-secondary institutions should prioritize programs that engage underrepresented students in hands-on science experiences during the high school years (Phelan et al., 2017). The American Society of Civil Engineers (ASCE), recognizing the importance of inspiring the next generation of civil engineers, has established a website for precollege outreach, which provides resources including lessons, videos, and activities that promote civil engineering (ASCE, 2020).

The Landscape of Minority High School Students

National trends indicate that high school graduation rates have declined, with African Americans and Hispanic graduation rates being approximately 65% (Heckman & LaFontaine, 2010). Minority students are also far less likely to be college ready. This is particularly the case in underserved minority high schools, where students are the least prepared (ACT, 2015; Bryant, 2015; Moore et al., 2010). Evidence of poor performance among minority high school students abounds not only in high school graduation rates, but also in SAT scores, Advance Placement courses, and enrollment in advanced mathematics courses (Musoba, 2010; Camara, 2013). These poor academic performances have been attributed to poor academic preparation. The National Assessment of Educational Progress (2015) found that overall only 33% of eighth grade students entering high school were proficient in mathematics. The corresponding percentages for African Americans and Hispanics were 13% and 19%, respectively. Since mathematics is the foundation of engineering degrees, there is an urgent need to strengthen these skills at the high school level.

City Tech's National Summer Transportation Institute

The National Summer Transportation Institute (NSTI) is an educational initiative developed by the Federal Highway Administration (FHWA) and Department of Transportation (DOT). A transportation-focused career awareness program, it is designed to introduce high school students to all modes of transportation-related careers, provide academic enhancement activities, and encourage students to pursue transportation-related courses of study at the college/university level. Moreover, the NSTI focuses on addressing future transportation workforce needs by ensuring that the transportation industry has a well-trained, qualified, and diversified workforce. City Tech was selected for funding by the FHWA and DOT in 2013, 2014, and 2015 to develop a NSTI for underserved urban high school students. A grant is provided to cover all costs related to the program in order to provide the opportunity to participants on a tuition-free basis. New York City is the ideal location, since it has both a diverse population and a complex transportation network. The College's location in downtown Brooklyn, New York, made it easy to recruit underserved high school students. City Tech is the designated senior college of technology within the 24-unit City University of New York, and it is the largest urban public university system in the nation. The college plays an important role nationally in the education of future scientists, engineers, technologists, and mathematicians for New York City (NYC) and the surrounding areas.

The mission of the civil engineering technology department at City Tech is to prepare non-traditional students of diverse backgrounds to successfully enter a wide range of careers through a balance of practical knowledge, theory, and professionalism. The department's mission aligns with the program objectives of the NSTI: to improve STEM skills, to promote awareness among middle and high school students (particularly minority, female, and disadvantaged youth) about transportation careers, and to encourage them to consider transportation-related courses of study in their higher education pursuits.

City Tech's NSTI summer program includes lectures, field trips, projects, and laboratory activities which promote the growth of each participant and strengthen their academic and social skills. The academic component is designed to reinforce the mathematics and science skills of the high school participants, to stimulate their interest in the various modes of transportation, and to expose them to new opportunities. The session topics are transportation related and are taught by certified high school teachers with a STEM background.

The skills enhancement component is critical to the success of the program. The topics covered include critical thinking, problem solving, computer literacy, research, oral and written communication skills, and time management.

The length of the summer program has varied; it was one week long in 2013, two weeks long in 2014, and three weeks long in 2015. The daily program schedule was from 9 a.m. to 4 p.m. and included a lesson, activity, lunchtime speaker, and field trip.

Curriculum Modules

Five curriculum modules were implemented in the NSTI: **(1) Bridges, (2) Land Transportation, (3) Air Transportation, (4) Public Transit and Railroad Transportation, and (5) Water Transportation.** A summary of each module and the course objectives is presented below.

Bridges

This module is designed to introduce participants to different types of bridges, structural forces, and geometry. Participants will be able to differentiate between materials and understand the force systems responsible for the stability of a bridge. The course objectives are to identify types of bridges, to understand the force distribution within a truss bridge, and to design a structurally sound bridge using principles of compression and tension.

Land transportation

This module introduces the interrelationship of land use and transportation systems. Students will be introduced to concepts of energy, force, motion, speed, velocity, and acceleration. The course objectives are to introduce participants to the process of land use and effective transportation systems, to identify data sources needed to make prudent transportation decisions, and to demonstrate an understanding of land use planning and ways to minimize transportation problems (i.e., congestion, noise, pollution).

Air transportation

This module introduces students to the concepts of flight theories, aircraft performance, flight instruments, gravity, air navigation, and space. Students will be introduced to concepts of force, projectile motion, center of gravity, velocity, and aerodynamics. The course objectives are to introduce participants to flight theories as they relate to airplanes and space and to explore a historic aircraft carrier and space shuttle.

Public transit and railroad transportation

This module describes the history of railroads and public transit. Participants will be able to summarize advantages and disadvantages of public transit systems in use today, in particular in the New York City area. The course objectives are to explore the social history of New York City, subway and station design, transit development, construction, and impact over time.

Water transportation

This module is designed to give participants an opportunity to learn the fundamental regulations and responsibilities of safe water transportation. Students will be introduced to the concepts of buoyancy and density, as well as to the engineering design process. The course objectives are to inform participants of the best water travel practices, and to identify possible threats and solutions to promote safe waterways.

Speakers

Participants were able to interact with professionals in the transportation field. These professionals were invited guest speakers sharing their own academic experiences and challenges with the participants while highlighting their careers and promoting the field of transportation. Speakers were representative of the various fields related to transportation and engineering.

Staff

The program staff consists of a project director, two instructors, and two academic aides. The primary role of the project director is to develop, implement, and direct all phases of the program, schedule, and budget and to supervise the program staff, develop curriculum, and provide laboratory activities and resource materials.

The primary role of the instructors is to provide daily academic instruction, interact with participants and administrative staff, and develop curriculum. The instructors are certified high school teachers, and as such have the training and background required to deliver the STEM-focused lessons and activities.

The academic aides assist the instructors throughout the day, set up laboratory activities, assist with coordination of field trips, and assist with orientation and closing activities. The academic aides are typically graduates of the civil engineering technology associate degree program at City Tech. The academic aides are also recruited from a group of trained peer leaders on campus. As peer leaders the academic aides bring to the program their knowledge of pedagogy and techniques for group facilitation.

Activities

The curriculum is reinforced with projects and laboratory activities. Participants are engaged in the engineering design process through hands-on activities and computer simulation applications. Computer-based activities include simulating bridge building and city planning. Hands-on activities include building a model bridge, solar car, boat, and rocket. The activities were preceded by a lesson or guest speaker introducing the relevant topics and careers in transportation. Participants worked both independently and collaboratively to complete the projects in preparation for testing and display.

Field Trips

Several field trips were organized during the NSTI. The participants had the opportunity to visit the Intrepid Sea, Air, and Space Museum, the NYC Transit Museum, the Brooklyn Navy Yard, and the U.S. Coast Guard Command Center, as well as John F. Kennedy International Airport. Each trip included a customized tour for the group aligned with the program focus of transportation and engineering.

FIGURE 1. Week 1 Sample Schedule

Week 1

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:00 AM	9:00-10:30 **Orientation &** Administrative Activities	9:00-12:00 **Lesson on Solar Energy** - Introduce scientific concepts of solar energy and physics concepts such as force, motion, speed, velocity, and acceleration. **Solar Car Design Project**	9:00-12:00 Lesson on **Bridge Design**- Introduce scientific concepts of engineering, structural forces, and geometry **Bridge Design Project** West Point Bridge Designer	9:00-12:00 **Lesson on Rocket Design**- Introduce scientific concepts of force, projectile motion, center of gravity, initial velocity, aerodynamics, and introductory rocketry. **Rocket** Design Project	9:00- 3:00 Field Trip US **Coast Guard Command Center** Topics: Careers at the Coast Guard, Deep Sea Freight transportation, Deep Sea passenger transportation, Inter-Coastal Waterway
10:00 AM					
11:00 AM	10:30-12:00 Team Building Activity : **Mousetrap Car**				
12:00 PM	12:00-1:00 Lunch **Presentation Topic: Civil Engineering and Transportation**	12:00-1:00 Lunch Presentation: The **Engineering Design Process**	12:00-1:00 Lunch **Presentation Topic: Transportation Planning**	12:00-4:00 Field Trip **Intrepid** Sea, Space and Air Museum Topics: Gravity, Air Navigation, Space	
1:00 PM	1:00-2:00 SIMCITY **Simulation**, Introduction to Projects	1:00-2:00 **College Skills**	1:00-4:00 Project **Model Bridge Building**		
2:00 PM	2:00-4:00 Project Mass **Transit Design - SIMCITY**	2:00-4:00 Field Trip NYC **Transit Museum** Topics: Public Transit/RR Transportation			
3:00 PM					3:00-4:00 **Waveglider** Design Project
4:00 PM	Dismissal	Dismissal	Dismissal	Dismissal	Dismissal

FIGURE 2. Week 2 Sample Schedule

Week 2

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:00 AM	9:00-10:00 **Library/Career Research**	9:00-12:00 **DOT Site Visit: K-Bridge Phase 2**	9:00-10:00 **Department of Buildings Safety Lecture**	8:00-2:00 Field trip JFK **Tour Topics**: Aircraft Performance, Flight Theories, Flight Instruments Arrive at Federal Circle at 9:30AM	9:00-11:00 Project Completion
10:00 AM	10:00-12:00 **Maglev Vehicels**		10:00-12:00 **Airplane Project**		
11:00 AM					11:00-12:00 Lunch Presentation Topic: **Strategies for Success in STEM**
12:00 PM	12:00- 1:00 Lunch Presentation Topic: DASNY	Lunch Presentation Topic: NYSDOT Highway Project	3:00-4:00 Guest Speaker: Waterfront Design		12:00-2:00 Poster **Preparation**
1:00 PM	1:00-4:00 **Field Trip : NY Waterway Ferry Ride**	1:00-2:00 **Lesson on Energy**: Converting potential energy into kinetic energy.	1:00-4:00 Field Trip **Brooklyn Navy Yard** Topics: Deep Sea Transportation, Inter-Coastal Waterway, History of Navy yard Tour begins at 1:30, 2 hourcustomized Sustainable Architecture and Industry Tour		
2:00 PM		2:00-4:00 **Project Boat Design**		2:00-4:00 **College/Career Advisement**	2:00-4:00 **Closing Program: Poster Presentation, Awards, Evaluations**
3:00 PM					
4:00 PM	Dismissal	Dismissal	Dismissal	Dismissal	Dismissal

Sample schedules are included as Figures 1 and 2.

Student Eligibility, Recruitment and Selection

At the time of participation, applicants must be a rising ninth, tenth, eleventh, or twelfth grader, qualify for enrollment in algebra, and hold a minimum cumulative GPA of 2.0 on a 4.0 scale. Graduates of the NSTI program are not eligible to repeat the program. The students are primarily recruited from City Poly High School and STEP-UP, a program of the McSilver Institute for Poverty Policy and Research. City Poly High School opened in September 2009 as one of four state-approved career and technical education (CTE) demonstration sites in New York City. The New York State Department of Education (NYSED) indicates that the 2015–2016 student demographics for City Poly were as follows: 75% black, 16% Hispanic, 4% Asian, 3% White, and 2% Other. In addition, 76% of the student population were economically disadvantaged (NYSED 2016). STEP-UP is a program designed by African-American and Latino adolescents (14 to 17 years of age) experiencing significant academic, social, and emotional issues for teens in similar circumstances. The STEP-UP participants were from Central Park East (CPE) High School. The NYSED has supplied the following demographics for CPE students in 2015–2016: 24% Black, 62% Hispanic, 8% Asian, 4% White, and 1% Other. Eighty-nine percent of the student population are economically disadvantaged (NYSED, 2016). These demographics are representative of underserved high school students.

Applicants submit a complete application with one letter of recommendation from a teacher or guidance counselor and a statement regarding their reasons for wanting to participate in the program and how the NSTI can assist in meeting their academic and career goals. The program director selects a cohort of 20 students, and a select number of applicants may be placed on a waiting list.

Methodology

Participants

A total of 41 high school students participated in the NSTI from years 2013-2015. There were 12 participants in 2013, which was a one-week program, 15 in 2014, which was a two-week program, and 14 in 2015, which was a three-week program. There were at total of 24 (58.5%) males and 17 (41.5%) females. Among the 41 high school students, 22 (53.7%) identified themselves as African American (non-Hispanic), eight (19.5%) as Hispanic, nine (22.0%) as Asian/Pacific Islander, two (4.9%) as Caucasian, and one failed to respond. The average age of the participants was 15.7 years. The average New York State Regent Mathematics and Science scores of the participants were 82.9 and 80.0, respectively.

Data analysis

On the last day of the NSTI, the high school students were asked to respond to statements regarding four areas: (1) speakers, (2) staff, (3) activities, and (4) field trips.

TABLE 1. Means and Standard Deviations for Students Satisfaction Survey Responses by Year

Statements	2013 N=12 Mean(SD)	2014 N=15 Mean(SD)	2015 N=14 Mean(SD)	Total N=41 Mean(SD)
Speakers				
Speakers were well organized.	3.3 (0.5)	3.9 (0.3)	3.4 (0.5)	3.6 (0.5)
I was academically challenged by the activities the Speakers provided.	2.8 (1.1)	3.9 (0.3)	3.4 (0.7)	3.4 (0.9)
Speakers responded well to the questions posed to them.	3.6 (0.5)	3.9 (0.3)	3.9 (0.3)	3.8 (0.4)
Staff				
The Staff was very interested in my career awareness.	3.2 (0.8)	3.8 (0.4)	3.8 (0.4)	3.6 (0.6)
The Staff was very helpful when I had problems.	3.6 (0.5)	3.7 (0.5)	3.7 (0.5)	3.7 (0.5)
The Staff encouraged participants to strive for excellence in all their academic pursuits.	3.5 (0.9)	3.8 (0.4)	3.8 (0.4)	3.7 (0.6)
The Staff was always available when I had a question or needed assistance.	3.5 (0.5)	3.9 (0.4)	3.7 (0.5)	3.7 (0.5)
The Staff was very friendly at all times.	3.4 (0.5)	4.0 (0.0)	3.7 (0.5)	3.7 (0.5)
The Staff was very knowledgeable about transportation-related careers.	3.8 (0.4)	3.9 (0.4)	3.9 (0.4)	3.9 (0.4)
The Staff was very enthusiastic about transportation-related careers.	3.6 (0.5)	3.9 (0.4)	3.8 (0.4)	3.8 (0.4)
Activities				
Project activities helped me understand transportation careers better than before.	3.8 (0.5)	3.9 (0.4)	3.9 (0.4)	3.8 (0.4)
Generally, adequate time was allotted for project activities.	3.0 (1.0)	3.9 (0.4)	3.4 (0.8)	3.4 (0.8)
Generally, adequate time was allotted for audience participation.	3.3 (0.5)	3.8 (0.4)	3.7 (0.5)	3.6 (0.5)
Project activities gave me some practical experience related to transportation.	3.3 (0.7)	3.9 (0.3)	3.9 (0.3)	3.8 (0.5)
Project activities often included competition between groups.	2.7 (1.3)	3.7 (0.6)	3.8 (0.4)	3.4 (1.0)
Field Trips				
Field trips were informative.	3.6 (0.5)	4.0 (0.0)	3.6 (0.5)	3.8 (0.4)
Concepts from the field trips were related to the field of transportation.	3.8 (0.4)	4.0 (0.0)	3.9 (0.3)	3.9 (0.3)
Field trip activities helped me understand transportation careers better than before.	3.6 (0.7)	3.9 (0.3)	4.0 (0.0)	3.9 (0.4)
Adequate time was allotted for project activities.	3.3 (1.0)	3.9 (0.4)	3.6 (0.9)	3.6 (0.8)
Adequate time was allotted for questions.	3.6 (0.5)	3.9 (0.4)	3.6 (0.9)	3.7 (0.6)
Transportation to and from the site was comfortable, safe and clean.	2.6 (1.1)	3.7 (0.5)	3.8 (0.4)	3.4 (0.9)
The number of field trips was appropriate.	3.6 (0.5)	3.9 (0.3)	3.9 (0.4)	3.8 (0.4)

TABLE 2. One-Way ANOVA Results

Statements	One-Way ANOVA
Speakers	
Speakers were well organized.	F(2,38) = 7.90, p<0.05
I was academically challenged by the activities the Speakers provided.	F(2,38) = 8.61, p<0.05
Speakers responded well to the questions posed to them.	F(2,38) = 4.08, p<0.05
Staff	
The Staff was very interested in my career awareness.	F(2,38) = 5.10, p<0.05
Activities	
Generally, adequate time was allotted for project activities.	F(2,38) = 4.26, p<0.05
Generally, adequate time was allotted for audience participation.	F(2,37) = 3.63, p<0.05
Project activities gave me some practical experience related to transportation.	F(2,38) = 4.93, p<0.05
Project activities often included competition between groups.	F(2,38) = 3.96, p<0.05
Field Trips	
Field trips were informative.	F(2,36) = 4.16, p<0.05
Transportation to and from the site was comfortable, safe and clean.	F(2,36) = 9.92, p<0.05
The number of field trips was appropriate.	F(2,36) = 3.38, p<0.05

A Likert scale with 1 indicating "strongly disagree" and 4 indicating "strongly agree" was used. Table 1 is a summary of the responses by year and collectively over the three years.

A one-way analysis of variance (ANOVA) was used to determine whether the mean responses were statistically significant among the years. Table 2 lists the responses that showed statistically significant differences. A Tukey test was used to follow up to determine the mean differences between each year. Overall the responses of the participants in 2014 and 2015 were most strongly positive to the statements that the speakers were well organized, the students were academically challenged by the speakers, the speakers responded well to the questions posed to them, and the staff was very interested in the students' career awareness. The activities and the field trips statements were also evaluated more positively by the 2014 and 2015 groups than the 2013 group.

Some of the high school students' reflections regarding the NSTI:

The U.S. Coast Guard trip was fun. It made me consider joining! (2013 participant)

John F. Kennedy Airport trip was a very new experience. The tour showed me there [were] more [jobs] in air transportation. (2013 participant)

I was very interested in Intelligent Transportation Systems; there were more things about information and technology and how it is used in transportation. (2013 participant)

In this first week, I have already learned a lot about a diverse range of topics from bridges, trains and kites. My favorite experience in the program so far has been making a kite constructed of string, straws and tissue paper, with my partner. I really enjoyed building a workable kite from few materials and being able to test the invention later. I had never really built something from nothing. The project also forced me to work with and depend on my partner. It was fun to collaborate and we were really proud with the end product. (2015 participant)

Conclusion

The results of the study showed high school students participating in the NSTI responded positively to the program. The participants felt academically challenged by the speakers, and they felt strongly that the speakers were able to address their questions and concerns. Students benefit from role models in STEM and can expand their interest in STEM by exposure to informal

STEM-related learning opportunities (Weber, 2011). Hands-on activities can stimulate interest in STEM and help students gain confidence in their ability to approach STEM activities (Colvin, Lyden, & León de la Barra, 2013; Ziaeefard, Miller, Rastgaar, & Mahmoudian, 2017). The students also found the field trips very informative. Many underserved students do not have the opportunity to be exposed to various careers, and field trips allow them to connect the importance of civil engineering to the real world.

This study also found that the length of the summer program made a difference in the participants' responses. The participants responded more positively to the speakers, staff, activities, and field trips when the program was either two or three weeks long. Better feedback responses came from the participants in the two-week program.

Lessons Learned

The NSTI offers an opportunity for students to be exposed to civil engineering and transportation fields while reinforcing their math and science skills. The most significant challenge of the program is recruitment, since the average high school student may not recognize the value of a STEM summer program. Several outreach efforts to advisors, parents, and counselors were made to encourage participation. The three-week program provided the students with one high school elective credit; however, it was difficult for students to commit for a three-week period because many of them had summer jobs. For two consecutive years, the program offered participants a stipend which helped offset the costs of participation. In 2015 the guidelines removed the allowable costs of stipends making recruitment more challenging. Students from these underrepresented populations residing in the five boroughs typically have to work during the summer to cover their expenses and assist their families. Participation in the NSTI offers a wonderful opportunity; however, it means the students have no income for the duration of their participation, and they have the added the cost of transportation. This study reinforces that stipends will allow for greater diversity in participation.

Epilogue

City Tech was selected to host the NSTI in July 2020; however, due to the COVID-19 pandemic the program was offered in a virtual platform. The curriculum remained the same, participants were expected to be available Monday–Friday from 9 a.m.–4 p.m. during the two-week period. Lessons and guest lectures were delivered via Zoom. Field Trips were delivered as virtual reality field trips using available technology. Students were provided a supply kit to complete projects individually and participated remotely in software simulations. In order to ensure that all eligible applicants could participate in the program, students were provided the opportunity to obtain a loaner Chromebook for the duration of the program. In addition, a stipend was provided to each participant to offset the loss of income they might incur by participating in the program. The program was a success and students were able to benefit from the experience in an alternate format.

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This project report is dedicated in loving memory of Janet Liou-Mark, a role model and a champion for all who were fortunate enough to know her.

About the Authors

Melanie Villatoro is an associate professor in the Department of Construction Management and Civil Engineering Technology at the New York City College of Technology (City Tech). She earned her BE degree in Civil Engineering from the Cooper Union and her MS degree in Geotechnical Engineering from Columbia University. Her outreach events target groups underrepresented in STEM with the goal of increasing the number of diverse qualified students entering the fields of STEM, particularly engineering.

Janet Liou-Mark is a professor of mathematics at City Tech, and she holds a PhD in Mathematics Education. Her research focuses on developing and evaluating programs that help women and underrepresented minority and first-generation college students to remain in school and successfully graduate with STEM degrees. She is the interim director of Faculty Commons.

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