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Crisis Teaching Online: Reaching K-12 Students through Remote Engineering Lab-based Activities During the COVID-19 Pandemic

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ABSTRACT

As schools were ordered to close due to the COVID-19 pandemic, K-12 teachers were given little time to prepare and make the transition to a remote environment. STEM teachers have the added challenge of converting lab-based activities into a virtual format. To determine how K-12 teachers can best be supported to provide distance lab-based experiences, an instructional module on adapting engineering lessons for remote delivery was incorporated into a research experience for teachers. Results revealed that teachers are concerned about the continued disruption and eager to learn techniques and best practices for teaching STEM online.

Key words: Remote laboratory, Engineering curriculum, Distance learning

INTRODUCTION

With little warning or training, K-12 teachers across the country were expected to transition from in-person instruction to distance learning within a matter of days in response to COVID-19. Most teachers continue to be in survival mode, trying to get through each week, and are eager to find solutions to offer authentic and engaging material to their students. Formal teacher education programs typically focus on preparing K-12 teachers for face-to-face teaching, with virtually no training for delivering content in a remote environment [1]. Those teaching STEM content have the added challenge of converting lab-based activities into a virtual format that can be delivered remotely.

Typical lab-based activities in face-to-face, K-12 STEM instruction include hands-on activities, laboratory work, simulations, demonstrations, and collaborative problem solving. The difficulty with translating these activities into a remote learning environment is maintaining the interactivity, authenticity, and accessibility of these lab-based experiences. In addition, the COVID-19 pandemic presents its own difficulties. Experts at the Imperial College London's J-IDEA group, who are modeling the trajectory of the current COVID-19 outbreak, suggest that socially disruptive interventions such as stay-at-home orders could be in place for an extended period [2]. As restrictions are lifted, they may need to be re-introduced in waves perhaps until a vaccine becomes available. This will require intense adaptability as teachers transition between face-to-face and remote learning throughout the current school year.

METHODS

In an effort to determine how K-12 teachers can best be supported to provide distance lab-based STEM experiences, a module on adapting engineering lessons for remote and online delivery was incorporated into a five-week virtual summer research experience for teachers and data were collected.

Eight K-12 STEM teachers (Figure 1) from across the United States were invited to participate in a hybrid research experience through the National Science Foundation (NSF)-funded Engineering Research Center for Bio-mediated and Bio-inspired Geotechnics (CBBG). Teachers were recruited from schools local to two of the four CBBG university partners, Arizona State University and Georgia Institute of Technology, plus a Primarily Undergraduate Institution (PUI) partner, Lafayette College and serving students from underrepresented groups.

Figure 1. K-12 STEM teachers and mentors: Each teacher presented their biogeotechnical engineering research and related developed lesson during the final two days of the virtual component of the program using Zoom. The faculty and graduate student mentors from all three universities, plus members of the education team joined the presentations to ask questions and offer support to the teachers.

The program included a mentored five-week virtual portion with both synchronous and asynchronous components delivered via Zoom and Canvas. With the support of CBBG mentors, six middle school teachers and two high school teachers developed engineering lesson plans to be implemented during the 2020–2021 school year as part of the program.

The asynchronous module (http://tinyurl.com/RETWeek4Module) in Week 4 focused on adapting engineering activities for remote delivery and included several components: webinars focusing on remote STEM lessons with lab experiences (Figure 2), training videos on facilitating equal access for all students by incorporating Universal Design for Learning (UDL) principles [3–4], various examples of how lab experiences might be replicated in a remote learning environment, and ideas for adapting STEM lesson plans for future learning disruption.

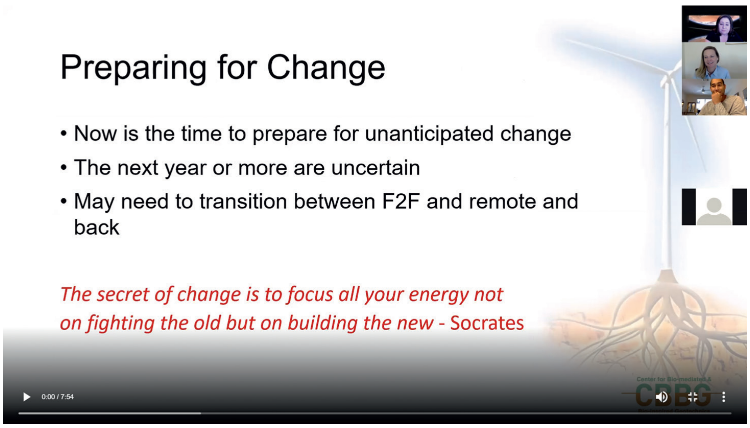

Figure 2. Webinar on preparing for online STEM teaching: As part of the Adapting Engineering Activities for Remote Delivery module, the teachers attended a training webinar focused on ways to effectively conduct lab experiences when students are not attending school in person. As shown on the presentation slide, teachers discussed what their schools plan to do in the fall, and how to design engineering lessons that could be flexible for both in-person and remote environments. A portion of the training webinar can be viewed here: https://tinyurl.com/preparingfordisruptedteaching

Teachers applied these concepts by adapting activities from their lesson plan for remote delivery. These ideas were posted in the Discussion Board with descriptions of how they will be modified to ensure equal access for all students. To check for understanding at the end of the module, teachers completed a brief Knowledge Check. The week's assessment included the following three questions related to adapting lessons for remote instruction: 1) *Please describe in 1–2 sentences some of the things you are doing now to prepare for continued disrupted learning during the next school year*, 2) *Please describe in 1–2 sentences what your concerns are for teaching STEM during next school year*, and 3) *Please share any ideas you have that you think might help the other RETs in their STEM lesson planning for next year*.

PRELIMINARY RESULTS

Analyzed using a grounded theory approach [5], the Discussion Board posts were coded and analyzed for emergent themes. The five most prominent themes which surfaced included: (1) issues of student accessibility and UDL, (2) use of at-home lab experiences in a virtual environment, (3) focus on authentic real-world learning, (4) use of videos (both synchronous and asynchronous), and (5) collaborative learning.

All eight teachers included some aspect of how they would modify their lesson for remote delivery, while ensuring equal access by incorporating UDL principles. For example, the use of closed captions on all screencast recordings, using translation software for students classified as ESL, and offering remote packets for students without a device or Wi-Fi access. Interestingly, three of the teachers explicitly mentioned their schools' providing technology to students including iPads, Wi-Fi hot spots, and printers. Those teachers' posts demonstrated high use of integrated technology, allowing lesson activities to be easily adapted to individual student needs per UDL principles. Teachers expressing concern about student access to technology focused heavily on providing access to instructional materials and not necessarily individual learning needs.

The theme of at-home lab experiences was evident in lesson modifications that included students collecting a soil sample from their yard and researching the makeup using a web-based soil survey (Figure 3).

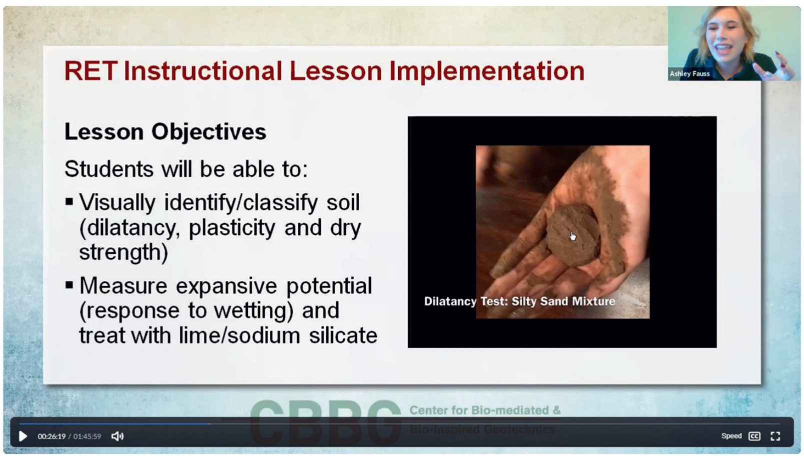

Figure 3. Engaging students at a distance: Eighth grade teacher Ms. Fauss sharing a video she made for students demonstrating how they will each test their local soil sample for its expansion potential. Developing lessons that use materials easily found at home is not only more engaging, but also a way to ensure equal access for all students. A portion of the lesson presentation can be viewed here: https://tinyurl.com/expansivesoilslesson

Another example included the use of engaging videos showing an “engineered wall” supporting a car’s weight and the teacher demonstrating the phenomena in the lab before students try the hands-on experiment at home (Figure 4).

***Figure 4.** Modifying for remote delivery. Mr. Trotter, a middle school teacher in Arizona, demonstrates his adaptability to modify his Bio-based Ground Improvement lesson for in-person or remote delivery. When teaching about Mechanically Stabilized Earth (MSE) in person, students work in small groups to build an “engineered sandcastle” in the school lab that can withstand their own weight. For a remote format, students watch an engaging video of an MSE wall supporting a car and another of the teacher demonstrating the phenomena before students try the hands-on experiment at home. This conventional ground improvement method introduces students to the use of biological processes for improving ground conditions.*

Teachers recommended sending materials to students for any lab-based activities that required items not commonly found at home (Figure 5), which not only facilitated at-home lab experiences, but also demonstrated a focus on accessibility.

Figure 5. Interactive lab set up at home: Middle school teacher Mr. Martin joined a research team at Lafayette College who is developing simple test kits for treating local soils. These inexpensive kits can be mailed to students at the middle school, high school, and college level for gathering data and contributing to a meta-data set for analysis. This image shows the materials and testing equipment needed to run a series of small bio-stimulated Microbial Induced Carbonate Precipitation (MICP) column tests, which were sent to the teacher's home. Mr. Martin will use the same lab set up with his students in the fall.

Several teachers mentioned developing lessons that could be delivered both in-person and online, regardless of their school's plans for the fall so they could be flexible in their teaching (Figure 6).

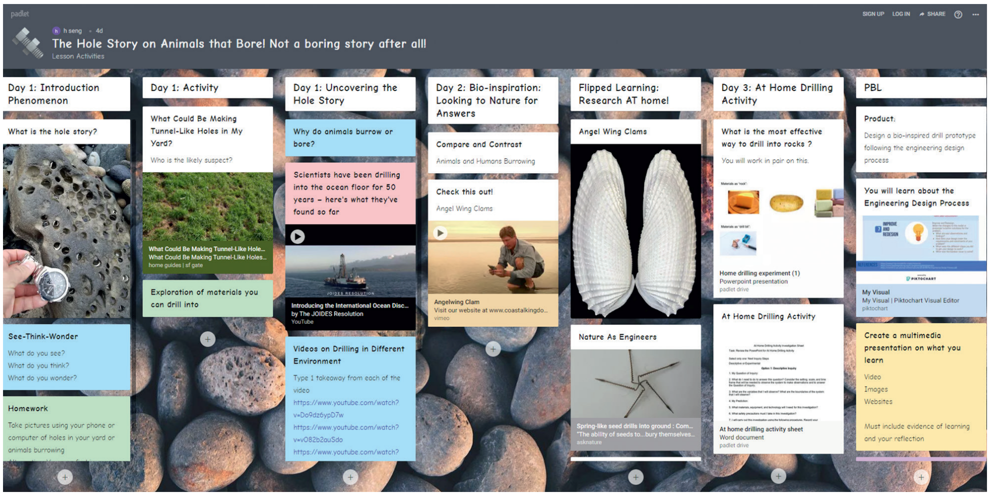

Figure 6. Designing lessons for in-person and remote format: Georgia teacher Ms. Seng organized all her lesson ideas using the online post- it board Padlet. She shared that by using this technology to house the pieces necessary to teach her engineering lesson (images, videos, presentations, interactive activities, at home lab experiments, worksheets, etc.), she would be prepared to teach the lesson online, in person, or both.

The theme of authentic, real-world learning also emerged in teachers' posts including the use of emissions data from U.S. energy sources, analysis of student neighborhood soil, and organizing an online scavenger hunt related to climate change data. Both synchronous and asynchronous video was used for a variety of purposes including modeling, collaborative learning, student-led presentations, direct instruction, and assessments. The theme of collaborative learning in remote environments also coincided with the integration of problem-based learning elements such as student-directed learning, scaffolding, and group reflections.

Teacher responses to the Knowledge Check questions illustrated the urgent need for more formal training on how to effectively transfer knowledge to students at a distance. One teacher worried about running "online courses and in-person prep" simultaneously and was anxious about "this new way of teaching." She stated that it "feels like I am coming into my first year of teaching again!" Another teacher shared her fear that students "will lose interest in science without seeing it in front of them." Some teachers were apprehensive because "not every teacher is on board" with teaching in a remote environment and may feel that it "takes away from the importance of their class." Several posts mentioned the concern that they will not be "able to do labs" or will have difficulty finding alternative ways of reaching students at a distance. One teacher posted "I am concerned with students being able to engage in authentic science practices when solely virtual."

NEXT STEPS

The COVID-19 pandemic will continue to impose new demands on teachers in terms of their ability to effectively communicate, engage, monitor, and motivate students at a distance. STEM teachers have the added burden of ensuring lab-based experiences are accessible for all students (http://cbbg.engineering.asu.edu/elearning). Results from the teachers' posts and questions revealed that there is a definite need for additional training and continued support throughout the academic year as disruptions are likely to continue.

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