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Lessons Learned from COVID That Have Been Transferred to Post-COVID Teaching and Learning

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Full Paper: Lessons Learned from COVID That Have Been Transferred to Post-COVID Teaching and Learning

Abstract

The COVID-19 pandemic required a rapid shift in course content delivery. Educators were faced with the challenge of providing some sort of continuity to student learning. Several content delivery modalities were used, including asynchronous, synchronous, and hybrid. The term HyFlex gained popularity, representing simultaneous offering of courses in-person, asynchronously online, and synchronously online, with students given the flexibility to engage through any of the modalities. New and innovative approaches to interactive learning were developed and implemented. Additionally, a transition to the online performance of laboratory experiments was required. Some of these new methods have carried over as we have moved back into more traditional education operations. In this paper, faculty from multiple institutions share success stories from techniques developed during the transition to online learning that have been transferred to or refined for the post-COVID in-person learning environment.

Introduction

A search of the ASEE PEER conference paper repository in May 2022 yielded over 200 conference paper results with the terms *Covid* or *pandemic* in the title and over 1270 results with those terms relevant to the article—all published over a 27-month period. Scanning the search results, one can see that the impact of the pandemic on many facets of engineering education was immense. Deeper inspection reveals a body of work that includes thought leadership, collegial conversation, and critical analysis of the impacts of the pandemic on all areas and concerns typically considered in the engineering education community. Scholars have documented and explored emergency remote teaching (ERT) and the implications to or impacts on accepted teaching pedagogies and teaching modalities, student learning and self-efficacy beliefs, challenges and opportunities with hands-on learning, and the systemic challenges related to inclusivity, equity, access, and engagement in engineering higher education. The enormity of the impact of the pandemic is underscored by the language of the pandemic ERT literature incorporating terms like disruption, survival, and coping.

Before delving into the authors' views regarding the value of enduring pedagogical and operational shifts that have resulted from teaching in a Covid environment, it is important to explore some key trends identified in recent literature. The shift to emergency remote teaching in the Spring of 2020 spawned a flurry of self-study, casual, collegial conversations, and consultations with teaching and learning support staff by engineering faculty around the country. In [1], it was found that throughout the second half of the Spring 2020 semester, participation in activities to assess and redesign teaching pedagogies, modalities, and assessments was high and sustained. Despite this increased energy around pedagogical conversation, self-study, and redesign, in [2] it was reported that the most common adaptation was a transition to a remote synchronous modality that "felt" the most like typical classroom teaching. In [3], Abel summarizes tips for creating successful learning environments in ERT, emphasizing open communication, peer collaboration, course simplification, and design for accessibility—principles that are essential to learning and engagement in nearly all course contexts. In the spirit of flexibility and in response to accessibility issues, many faculty members employed HyFlex pedagogies in their classrooms, and the success of the HyFlex pedagogy in an introductory design classroom using many different online tools (Miro, Zoom, Teams, MS Forms, Canvas

LMS, etc.) was reported in [4]. Redesign of the learner's experience in this environment required consideration of the equivalency (same learning opportunity regardless of the mode of access), reusability (the ability for everyone to reference learning artifacts generated through all modalities), and general accessibility (opportunity for learners to connect with learning experiences regardless of their location or technological constraints) of the course content and experiences [4]. In [5], efforts by faculty to connect with students on many fronts through many channels, including email, SMS messaging, synchronous teleconferencing, asynchronous video messages, virtual office hours, and discussion forums or boards were reported. Despite these efforts, both faculty and students reported decreased engagement and reduced student-student and student-faculty communications as obstacles to learning [5].

Universal to the approaches detailed above is the goal of creating an environment where learning can thrive, and desired outcomes can be attained. In response to the emergency shift to remote teaching, the design principles of *accessibility*, peer *collaboration*, *communication*, *equivalency*, *reusability*, and course *simplification* emerged. In this paper, the authors will discuss instructional changes that were born out of ERT innovations that have been further adapted and adopted for enduring use in their engineering classrooms. The interventions/innovations will be connected to the design principles listed above with a parenthetic notation next to the section heading, as appropriate.

Project Approach

A summary of participating institutional metrics can be found in [6]. Briefly, the schools range from small, private military institutes (1700 students on campus) to large private universities (15,000 students on campus).

1. Content Delivery (Accessibility, Communication, Equivalency, Course Simplification)

Intro to Engineering courses are continually evolving. Prior to the pandemic, the FYE team at Drexel University (DU, a large private university with 500 FYE students) was completely redesigning their Intro to Engineering course in preparation for the Fall 2020 semester. The team developed an initial curriculum that was designed for virtual instruction, with up to 95% of assignments converted to a digital format and submitted to the LMS for grading, including quizzes and homework assignments. Similar work has been carried out by Norwich University (NU, a small private military/civilian university with 125 FYE students covering 5 majors) through the integration of the iPad into the engineering curriculum [7]. While initially used to digitally ink notes (professors and students) and as a course and laboratory notebook (students), the iPad has since been used to deliver/take/grade exams. Multiple students have attributed improved organizational skills and efficiency of studying to their digital tablet use.

In addition to uploading written assignments, Virginia Military Institute (VMI, a small private military institute with 30 FY ECE students) has required students to submit videos demonstrating the functionality of projects or lab exercises and explaining their results. This has proven both helpful for grading and formative for students helping them synthesize info and recognize the most significant concepts.

One of the most significant results of teaching during the pandemic has been the increased use of virtual platforms for invited guest speakers. Professors can open the classroom to anyone from anywhere. The authors have previously discussed a multi-institution, multi-year project involving a guest lecture to FYE classes [6]. This effort has included in-person presentations

(pre-pandemic), “live” virtual presentations, and recorded sessions. The availability of live or pre-recorded video resources is an easy way to enrich a course by bringing in additional perspectives or expertise while also breaking up the monotony of hearing one voice lecturing. The increased availability of these pre-recorded resources and the generally increased comfort in engaging with virtual speakers has led to much more regular use of this approach in the in-person classroom.

2. Cloud-Based Simulation for Laboratory Exercises (Accessible, Collaboration, Reusable)

The transition to online learning during the initial stages of the pandemic was especially challenging for courses with a hands-on laboratory component. Access to specialized laboratory equipment was either not possible (remote) or complicated (socially distancing). To continue achieving course objectives, the discipline-specific FYE course at NU transitioned to using circuit simulation software to perform laboratory exercises. This course utilizes electrical engineering equipment weekly and integrates the Arduino UNO microcontroller into many of the lab exercises. TinkerCAD was used to perform many of the traditional hands-on experiments in simulation. This online tool allows for circuit simulation and includes a working model of the Arduino UNO. As a specific example, the course’s final project uses an in-house built circuit and spectrophotometry to measure the level of contaminants in a water sample [8]. Shown in Figure 1(a) below is the in-person implementation of the assembly, including a message displayed on an LCD shield connected to an Arduino UNO. Students interface the Arduino with the circuit assembly (green box) and develop a simple GUI driven by push buttons on the shield (blue box). Shown in Figure 1(b) is an example of this experiment implemented in TinkerCAD. Push buttons and power supplies are used to mimic the buttons on the shield (blue box), while a single power supply (green box) is used to simulate the entire spectrophotometer assembly.

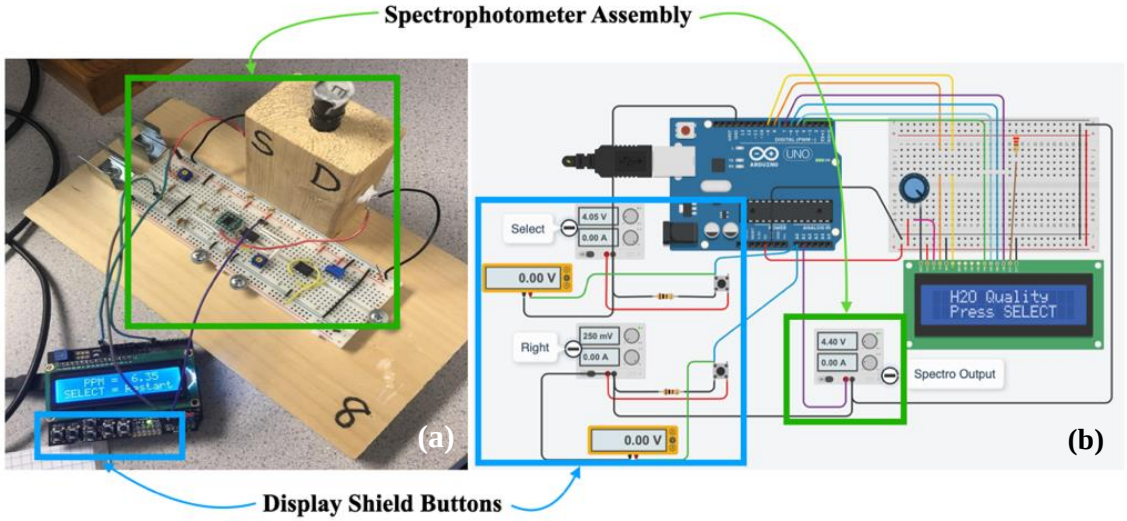

Figure 1. (a) Physical circuit assembly used in-person and (b) assembly simulated in TinkerCAD.

Since returning to in-person instruction, TinkerCAD and other circuit simulation software packages have continued to be used to demonstrate fundamental principles in the classroom, to introduce or supplement laboratory exercises, and to serve as pre-lab exercises. The same package has been used for similar purposes at VMI. This tool has also proven useful for students

to check their work, probe their understanding, and visualize course content, improving students' understanding. More classical, locally installed packages were used in the past at VMI, but accessibility and peer collaboration were greatly improved as a result of shifting to this cloud-hosted platform.

3. Online Community Building (Peer Collaboration)

Remote/online tasks through the LMS can be effective at building community, even for in-person courses. Starting with "introduce yourself" tasks implemented as 90-second videos, 1-page slide decks, or discussion forum posts can help students connect and communicate with each other, building community regardless of the class modality or means of access. Team formation can take many forms that range from randomly assigned, to assigned using metrics such as student interest or GPA, to self-selected [9]. There are also benefits to interactively forming design groups through online platforms. Engineering design is an integral component of many first-year engineering programs [10]. As part of an engineering design experience, a project-based based approach is often utilized wherein students work in teams. At Wentworth Institute of Technology (WIT, a medium-sized private university with 500 FYE students covering 8 majors), group formation in first-year courses has ranged from skills-based group assignments [11] to self-selected groups based on a shared common interest. Prior to the move to remote learning, the latter approach utilized in-class presentations and peer-to-peer interviews. Although this provided an effective model for some students, participation in the activity varied from student to student. This resulted in the more introverted students ending up in a group that did not necessarily reflect their interests. In the move to online learning, this in-person presentation/interview approach shifted to an online discussion board facilitated through the University's LMS. For this, students were prompted to introduce themselves, identify their relevant skills, and specify the general topic areas they were interested in. After posting, students were instructed to reply to the post from one of their peers and begin a discussion. This resulted in students forming groups over a relatively short period of time and the appearance of ongoing conversations about shared interests through the discussion board. The use of the discussion board appeared to allow students to explore topics outside of the physical classroom setting, which allowed the students to be more invested in the team formation process resulting in groups that appeared to be more motivated and excited to work on a given project.

Results and Discussion

A survey of students whose first year was interrupted by the pandemic and whose most recent year was as close to "normal" as possible revealed a few interesting themes. Some students commented that the shift to ERT resulted in an improvement in their digital organization and authorship skills, ultimately resulting in their acquiring tablets and lasting improvements to their overall study efficiency. Other students reported that during ERT, the recording of lectures and the creation of video repositories greatly increased. These curated resources were essential during the shift to online teaching but have proven to be valuable resources to the students in the return to the more traditional classroom environment. One student commented that while they used YouTube and other video repositories previously, prior to the pandemic, they did not routinely take notes while watching online videos. After Spring 2020, they learned to take notes and make the information "their own" when accessing any online resource and that this change is something they have continued, and it has improved their ability to learn on their own and improve their own academic performance. Interpreting the students' comments and sentiments, it

was clear that using the supplemental video resources, and taking notes throughout those "viewing" sessions, improved the students' ability to synthesize information from multiple sources.

During the pandemic, guest lecturers were invited into the virtual classroom to reinforce course material. Initially, the lectures were presented in real-time and included a Q&A period with the students. Subsequently, there appeared to be value in recording the lectures and having students who did not attend the lecture review the recording at a later date. This offline/asynchronous approach had its drawbacks in that students appeared to be less engaged in the recorded lectures (due to the length of the lecture as well as the perception of a detached interaction with the speaker). Upon return to the classroom (face-to-face instruction), it was observed that the students in the classroom preferred "real-time" in-person interaction with the guest speakers over the virtual presentations—with the "live" virtual presentations ranking second, and the recorded presentations ranking third. Although the impact of having guest speakers varied according to the type of delivery, the value of the concept was recognized as useful and effective.

The positive impact of practices that were implemented during the move to online learning could also be measured quantitatively. At WIT, the implementation of online discussion boards for design group formation had a notable impact on the ability of teams to function on multidisciplinary teams. Prior to the pandemic, in-person team formation was utilized, and students were evaluated through peer evaluation at the conclusion of the semester on their ability to function on teams (ABET Outcome 5). When comparing the impact of the online discussion board approach, it was noted that there was an increase in student performance, as illustrated through the peer assessment (Table 1).

Table 1. The impact of team formation methods on student performance on student teams. (*Data was not collected in 2020).

	2018 (n=13)	**2019** (n=26)	**2021** (n=15)
Team formation method	Students formed teams based purely on diversifying the skillset within the group	Students formed teams based on diversifying the skillset within the group with a focus on identifying a shared interest	Online Discussion boards used wherein students were instructed to diversify the skillset within the group with a focus on identifying a shared interest
% of students evaluated as satisfactory performance by their peers	82%	90%	100%

Conclusion

In this paper, multiple instructional changes that were born out of ERT innovations and further adapted and adopted for enduring use in their engineering classrooms have been discussed. The incorporation of online tools and modalities allowed the students to continue to meet learning objectives related to experimentation, communication, and teaming skills regardless of physical location. Deep integration of digital devices into courses for lecture presentations (with screen recording), notetaking, problem-solving, and exam administration aided in remote instruction and has been continued due to improved reusability and equivalency. The use of online

simulation tools (such as TinkerCAD) to perform traditional hands-on experiments in simulation has been adapted to serve as pre-lab assignments, for improved student exploration, or for students to compare data collected in the laboratory to expected/theoretical results. It was also found that remote/online tasks administered through a learning management system (LMS) can be effective at building community regardless of the course modality. By starting those tasks in the online environment, even for an in-person class, the resultant student engagement and connection-making can continue beyond the limited duration of an in-class exercise. The submission of student-narrated video explanations of their homework problem solutions or lab exercise results helps to promote student understanding of the subject matter and can serve as a learning resource that is reusable and accessible. The opportunity to have guest speakers virtually in the classroom from anywhere in the world became easier, more prevalent, and more comfortable—and the use of virtual visitors has been maintained.

References

[1] A. P. Rehmat, H. A. Diefes-Dux, and G. Panther, "Engineering Instructors' Self-reported Activities to Support Emergency Remote Teaching During the COVID-19 Pandemic," in *2021 ASEE Virtual Annual Conference Content Access*, 2021.

[2] D. Fadda, Rios, O., Vinay, R. , "Teaching Modalities During the COVID-19 Pandemic," presented at the ASEE 2021 Gulf-Southwest Annual Conference, Waco, Texas, 2021, 36407. [Online]. Available: https://peer.asee.org/36407

[3] K. D. Abel, "Effective Online Teaching Practices during a Covid Environment," in *Middle Atlantic ASEE Section Spring 2021 Conference*, 2021.

[4] C. M. Wigal, "Teaching the Design Process in a HyFlex Environment," *Journal of Higher Education Theory and Practice*, vol. 21, no. 10, 09/30 2021, doi: 10.33423/jhetp.v21i10.4637.

[5] U. J. T. Garcia, K. Pakala, S. Schauer, D. Bairaktarova, and B. Chittoori, "Evaluating STEM Course Re-Design Strategies in Light of COVID-19," in *2021 ASEE Virtual Annual Conference Content Access*, 2021.

[6] R. J. Marino, M. Cross, D. M. Feinauer, J. R. McCusker, and J. P. Casale, "Including Multi-Disciplinary Project Awareness in First Year Introduction to Engineering Courses," in *2021 First-Year Engineering Experience*, 2021.

[7] M. Cross and D. M. Feinauer, "Full Paper: Integrating the iPad Into the Engineering Classroom (Resubmission)," in *2021 First-Year Engineering Experience*, 2021.

[8] M. Cross, D. M. Feinauer, M. W. Prairie, and S. H. Frisbie, "Tackling Real-World Problems in First-Year Electrical Engineering Experiences," in *2019 FYEE Conference*, 2019.

[9] L. C. J. L. Brickell, L. C. D. B. Porter, L. C. M. F. Reynolds, and C. R. D. Cosgrove, "Assigning students to groups for engineering design projects: A comparison of five methods," *Journal of Engineering Education*, vol. 83, no. 3, pp. 259-262, 1994.

[10] K. Reid and D. Reeping, "A classification scheme for "introduction to engineering" courses: defining first-year courses based on descriptions, outcomes, and assessment," in *2014 ASEE Annual Conference & Exposition*, 2014, pp. 24.24. 1-24.24. 11.

[11] J. McCusker, H. Pritchard, and J. Sosnik, "Synthesizing an Interdisciplinary Design Environment in First Year Engineering Education," *Proceedings of the 8th First Year Engineering*, 2016.