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Bouncing Forward from COVID in Higher Education

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ABSTRACT

This paper is a call to arms to bounce forward in the classroom as we emerge from the COVID crisis. The predominant return to in-person classes in higher education should not be a return to the same normal classroom conditions that existed prior to the pandemic. In the last 2+ years, we have come an extraordinarily long way in our abilities and in our inclinations to employ technologies and techniques in a blended classroom environment that truly improves the learning experience. In this paper, we call for and contribute to such an effort. Tying into the abundance of literature dealing with the COVID educational environment, we present our findings and ideas from carefully studying our own faculty. We summarize our overall findings as well as describe in detail three general categories that we believe hold great promise for improving the higher education classroom in the post-crisis era, namely digital chalkboards / screen sharing; remote participation and collaboration; and a paperless classroom. We argue that educators have an obligation and opportunity to not simply return to pre-crisis methods.

CCS CONCEPTS

• **Applied computing** → **Collaborative learning**; **Computer-assisted instruction**; **Interactive learning environments**; *Distance learning*.

KEYWORDS

COVID, principles of teaching, STEM education

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1 INTRODUCTION

The onset of the COVID pandemic in spring 2020 resulted in sacrifice, adaptation, and innovation by educators in information technology as well as across the rest of higher education. Classes moved online with students and teachers interacting through webcams, microphones, videos, and screen sharing. Virtual class participation, followed by hybrid class participation, became the norm. Many of the innovative "mitigation" techniques produced during the crisis have been well documented in literature, as is highlighted in the background section of this paper.

As the preponderance of institutions now return to in-person classes in a post-pandemic world, this paper argues that rather than bouncing back to normal, we have the obligation and opportunity to instead bounce forward from the pre-COVID normal, producing an educational experience and environment that is more conducive to learning and high quality instruction than it was previously.

This paper's goal is to call for and contribute to such an effort. After a literature review, we present the results of a survey of our department's faculty that reports on what COVID-related techniques they are still employing. We then describe in detail three general categories of techniques that enhance the post-COVID classroom (Digital Chalkboards / Screen Sharing; Hybrid/Remote Attendance, Participation, and Collaboration; and A Paperless Classroom).

Like most institutions, our instructors discovered helpful resources and invented alternative methods to meet learning objectives. As institutions largely return to in-person learning, educators, particularly those in computing classes, should continue to benefit from the past 2+ years of effort. The post-COVID educational experience should be better, stronger, more flexible, and more accessible than it was pre-crisis.

2 BACKGROUND

The most comprehensive related work is the 25-page report "Teaching through a Global Pandemic: Educational Landscapes Before, During and After COVID-19" produced by a Working Group from the 26th ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE 2021)[15]. This 12-person effort consists of three major parts.

Part 1 of the ITiCSE 2021 working group report [15] identified and analyzed 80 relevant publications collected from a variety of venues that included SIGCSE, ITiCSE, ICER, UKICER, Koli Calling, FIE and EDUCON as well as several journals. The analysis

of these publications was broken out in five categories: (1) pedagogy and practice; (2) value changes; (3) inclusion and diversity; (4) community, belonging and wellbeing; and (5) academic integrity. Two categories from this analysis are extended and complemented by our work. The pedagogy and practice section of their report analyzes several innovations and adaptations describing course structure/design involving integration of tools and technologies to support a blended classroom. We believe one difference between our specific work and that reported on by the ITiCSE 2021 working group is that most of the papers they analyzed were describing how to react and transition to a COVID environment whereas our work is focused on a post-crisis environment.

Part 2 of the ITiCSE 2021 working group report [15] describes the construction and results of a multinational survey of 180 computer science teaching faculty which focused on the COVID transition to remote learning, specifically addressing pedagogy and practices, technology use, and assessment practices and their connections with academic integrity. This informative and inspiring section of the report provides numerous descriptions from the field on how our profession reacted and creatively adapted to the transition to remote learning and a blended environment. We believe our paper takes this valuable information even further as we directly address how we should bounce forward into the new normal.

Part 3 of the ITiCSE 2021 working group report [15] provides recommendations for moving forward. Suggestions include best practices for leveraging technology for teaching, how to better support faculty and student well-being, and a call for future computing education research in the areas described. We view our work as addressing this call.

Although the ITiCSE 2021 working group report was a superb contribution to the body of knowledge, its one major shortcoming is that it did not survey and include the significant number of relevant COVID-related publications from the 2020 and 2021 ACM Conference on Information Technology Education (SIGITE). In our literature review, we found at least nine potential SIGITE papers [1–7, 14, 17], along with several other posters and panels, that should have potentially contributed to the ITiCSE 2021 working group effort. Although we found all of this work valuable, the papers most relevant to our current work were those that dealt with course structure/design and integration of tools and technologies to support a blended classroom [1, 4, 7, 17]. We believe our paper is a worthy next step to the 2020 and 2021 SIGITE contributions in this area.

3 POST-COVID TECHNOLOGY USE IN THE CLASSROOM

At the height of the COVID crisis, colleges canceled in-person education and faculty were asked to teach remotely. To facilitate remote education, teachers used a variety of technologies. They often conducted class using videoconferencing technologies such as Zoom, or they posted lesson videos on learning management systems such as Blackboard and Canvas.

Educational technology certainly precedes the COVID pandemic. Devices such as smart boards have been available for use in many institutions, yet often teachers did not use them [10]. The transition

to fully remote instruction necessitated instructors' re-acquaintance (or acquaintance) with some of these platforms and technologies.

With the return to in-person education, we were interested in determining if any educational technologies prevalent during COVID were still being used in the post-COVID environment. In Figure 1, we report the results of surveying computing faculty at our institution to determine whether they were continuing to use technologies and techniques introduced to their classrooms during COVID.

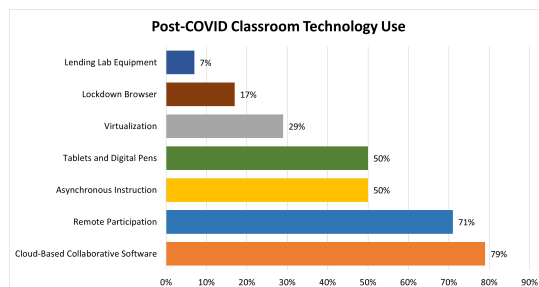


Figure 1: Technologies and techniques still being used which were initially used as a result of COVID

Seventeen of our institution's instructors completed our survey. 76% (13/17) reported continuing to use technologies and techniques in the classroom that they only began using primarily in response to COVID. Of those continuing to use COVID-initiated technologies, many reported continued use of digital writing technologies (e.g., projecting a touch screen tablet with stylus so the class can see what the teacher is writing) while others reported using screen sharing to view student work or allow students to present work to the class. Other continued uses of technology include asynchronous instruction (for example, recording a lecture), virtualization, and remote attendance.

We also asked our instructors to share descriptions of how they continued using technology in the classroom. We provide several of these examples as vignettes. From the survey and instructor feedback, we identified three trends in how technology embraced during COVID is still being used in the classrooms. These trends include digital chalkboards, remote accessibility, and a paperless classroom.

4 PRACTICE 1 - DIGITAL CHALKBOARDS

The chalkboard has been used for centuries to aid instruction by providing a visual medium for instructors and students. Modern substitutes such as PowerPoint can be animated and provide more detail than visuals created on a chalkboard or whiteboard. While studies have found little difference in efficacy between chalkboard based lectures and lectures presented using PowerPoint [13, 16], one study found that students overwhelmingly (81.7%) prefer a blending of PowerPoint presentation with "chalk-and-talk" lecture [19].

Digital pen technologies make it easy to combine digital presentations with "chalk-and-talk." Although digital pen technologies have been around for many years in various forms (such as smart boards), most teachers have not fully embraced this category of technology [10]. One of the main reasons cited by teachers was

that they did not fully know how to use such tools. The forcing function of COVID combined with the modern tablet and stylus – which allow for intuitive writing on PowerPoint presentations and other file types – may be a tipping point for the adoption of digital chalkboards.

The benefits of chalkboards can be leveraged more completely using modern technology. In addition to the teacher's presentation of material, chalkboards allow students to demonstrate their learning as well. Collaboration platforms allow multiple students to contribute concurrently onto a shared canvas. Instructors can broadcast students' work for the benefit of the rest of the class [8]. Sharing platforms allow instructors to observe individual students' work without moving around the room, and see, assess, and correct work as needed.

4.1 Vignette - Screen-sharing in an Introductory Computer Programming Course

Instructors in an introductory computer programming course first used Replit to teach their course during COVID. Replit is an online, collaborative, integrated development environment (IDE) that enables teachers to view and comment on students' coding projects online live while students are working. The platform provided an environment for students to code together even if they could not physically collocate. The tool worked equally well during and after the pandemic. Having returned to the classroom, Replit is still used to allow students to share and explain their code with the class without needing to leave their desks or rewrite voluminous programming statements on the board.

4.2 Vignette - Screen-sharing in a Distributed Applications Course

Like many other educators, the instructors of our Distributed Applications Design course had to adapt to the changes brought by COVID. The course features a project where students deploy a web application with both a web front end and a database back end. Students have designated times throughout the course to work on the project during class – called in-class exercises. Before COVID, the instructor would walk around the classroom, observe the students over their shoulder during the development and deployment operations, and answer questions. COVID eliminated the ability to conduct these in-class exercises in-person, which was an essential part of instruction for the class.

To get around the limitations of remote "in-class exercises," the instructors turned to the management facilities inherent to many virtual machine infrastructures. Rather than developing their projects on their laptops, students instead were directed to conduct development on virtual machines hosted on the department's IT infrastructure. The management tools allowed instructors to view the students' desktops while they worked and actually improved efficiency and the quality of instructor feedback.

4.3 Vignette - Improved Classroom Infrastructure with Screen Writing

During COVID, some institutions temporarily implemented a blended or hybrid classroom in which some students attended class in-person while some attended remotely. In an introductory computer science course taught in a hybrid environment, instructors used Wacom tablets as a substitute for whiteboards. Instructors used the tablets to write annotations on slides for the benefit of the remote students. After COVID restrictions ended, instructors continue to use this setup. Writing on the tablet and projecting to a screen allows the instructor to remain in place. It also facilitates the accommodation of remote students who are unable to see the whiteboard.

5 PRACTICE 2 - REMOTE PARTICIPATION AND COLLABORATION

During the pandemic, instructors relied on videoconferencing technology with students and teachers interacting through webcams, microphones, and online chat. The technologies used to facilitate remote learning can still be used to enhance in-person learning. Instructors can use the remote participation technologies to expand the classroom in a number of ways such as providing access to non-local guest lecturers or allowing students who cannot be physically present (for example due to illness) to attend the class remotely. Conversely, the instructor can conduct the class remotely if unable to physically attend. Instructors can also increase their accessibility via adding virtual office hours or conducting small meetings remotely.

5.1 Non-Local Guest Lecturers

Instructors in higher education often have relationships with experts and leaders in their field. It is a common practice for these experts and leaders to give a guest lecture to a course. Guest lecturers may not have the time to come speak to a class if they are not local. This difficulty can be obviated through videoconferencing technology. One of the instructors in our survey discussed a guest lecturer who taught one lesson per semester. The guest lecturer conducted a burdensome commute every semester but transitioned to a virtual lecture during the pandemic. When in-person classes resumed, the guest lecturer maintained his remote option. The students attended class per normal but the lecturer spoke from a screen at the front of the classroom. Cameras and microphones in the classroom allowed the lecturer to interact with the students. This use of technology provided students almost the same experience they would have received if the lecture was in-person.

In another example, a professor had relationships with several high-profile cyber experts and leaders. These individuals were willing to speak to students, but travel to the institution was not always feasible. It was often easier to schedule an hour to give a remote lecture. This method also allowed the audience to expand. The attendance capacity for meeting software far exceeds that of most physical classrooms. Lectures and visits facilitated by such software allowed the participation of other faculty and students across the university.

5.2 Attend Class Remotely

COVID made remote teaching the norm as both students and faculty learned to use the associated technologies. After the initial fully remote response, some experimented with hybrid/blended modalities where part of the class was remote and part was physically present [18]. Although these dual-teaching arrangements are generally less optimal compared to in-person classes, they do provide an alternative over completely missing a class and should continue to be used in some situations.

Some instructors in our survey discussed how they continue to use a dual-teaching technique. Even after the pandemic, students who contract COVID must self-isolate and are unable to attend class. The instructor is able to teach the class in-person for all but the one student, who attends remotely using videoconferencing technology. The instructor shares his screen for the benefit of the remote student. When the alternative is missing class, this approach is satisfactory. The remote student can observe the lecture, participate in discussions, and even share his screen with the class. Instructors reported using this method for all categories of absent students - including those participating in athletics or club activities.

Teachers can also benefit from the flexibility that collaboration software provides. Prior to COVID, the standard practice for an instructor who could not physically attend class would be either to cancel class or find a substitute teacher. Especially for advanced topics, a substitute may not be a feasible option. Post COVID, there is a new alternative: the teacher can participate remotely while the rest of the class attends in-person. As an example, an instructor at our university was permitted to assist with an important government project where her expertise would be critical. However, there was no one else available with comparable knowledge that could teach her upper level software engineering course. Rather than cancel the class, she taught remotely while the students attended in-person. For each lesson, an assistant prepared the classroom to enable the instructor's remote participation and the assistant remained present throughout the classroom to monitor and address any issues. During the class, the instructor presented the course material as if physically present. The instructor felt it was important to have the students physically present in the classroom so they would stay more engaged and the instructor's assistant could help hold them accountable. At the same time, the instructor felt engaged with the class because, in part, she could physically see all the students and interact with them in a manner similar to how she would were she in-person.

5.3 Remote Meetings

From office hours to project meetings, pre-pandemic courses typically held all meetings in-person. While there are clear benefits to in-person interaction, it is not always possible to be physically present. Virtual meetings are an alternative.

The primary way students interact with instructors outside the classroom is through so-called office hours. Office hours are typically set at specific times and conducted in-person. Circumstances, though, sometimes make it difficult for students and teachers to be physically present at office hours. Virtual meetings are an alternative instructors embraced in response to COVID. For years, online courses have held virtual office hours. Students use virtual

office hours in largely the same way they use in-person office hours but studies show students are more satisfied with virtual office hours [11]. During COVID, instructors had to use remote office hours and it can be tempting to revert back to only in-person sessions. However, instructors should consider offering some portion of their office hours virtually or allowing students to a priori schedule virtual office hours. The same holds for other meetings with the instructor such as project progress meetings.

5.4 Considerations

Although remote participation is an option for in-person classes, there are some important considerations. During the pandemic, remote students indicated they were less motivated and engaged [9, 12]. Additionally, a recent study indicates students prefer in-person learning [18]. Therefore, efforts should be taken to minimize the number of people attending remotely. In the case of a remote expert or teacher, we advocate only the presenter attend remotely with the class attending in-person. In the case of remote office hours or remote meetings, they seem to work best when the group size is small. A general rule we use is four or fewer people for a remote meeting.

6 PRACTICE 3 - A PAPERLESS CLASSROOM

Learning management systems (LMS) are well established. For years, courses have been taught using Canvas, Blackboard, and Moodle amongst other systems. These systems all provide a way to turn in assignments, present material, and administer in-class graded events electronically. However, prior to the pandemic, many in-person courses that used an LMS for various functions still issued and required students to turn in assignments on paper. With the advent of the pandemic, remote instruction made it impossible to use paper assignments. As a result, many teachers converted assignments to electronic format and students turned them in via the LMS. Instructors then graded the assignments, providing feedback digitally. The digital feedback may have been provided using features built into the LMS or by writing directly on the assignments, either digitally with a tablet / touch screen or by hand and then scanning in the feedback.

As one professor who took our survey stated, "Before COVID, nearly all homeworks and labs were collected as hard copy. Since COVID, they are all electronic submissions. I grade them by writing within the electronic files directly and return them electronically to the students. This also allows me to keep a copy of the graded work. Before COVID, homeworks and labs were due at beginning of class. Now, all sections turn in assignments electronically via Canvas at the same date/time." Another professor stated, "I now maintain a fully digital submission/grading process and no longer use paper submissions for quizzes, lab reports, and problem sets."

There are clear advantages to online submissions and feedback over analog. First, teachers know exactly when a student submitted an assignment. Second, using the LMS for submission and feedback provides an organized location where students can view the feedback. In contrast, it is easy to lose or misplace a paper assignment. Further, the feedback is organized making it easy for the student to review when convenient. Third, teachers can assign due dates to digital assignments in LMSs and students will see reminders

as the due date approaches. Finally, a paperless classroom with improved technologies (and improved user abilities with said technologies) now makes collaboration among students easier to do as they no longer need to exchange papers or printouts, but simply electronically share things with each other.

7 CONCLUSION

As we have highlighted throughout, the COVID pandemic resulted in significant advances in technologies, pedagogy, and perhaps most salient to our point, user abilities and user proclivities. COVID initially forced educators across the country to teach remotely. As the pandemic transitioned to an endemic, schools have returned to in-person, or sometimes blended, educational environments. However, technologies and techniques embraced during the height of the COVID crisis should still be used to enhance education. In particular, through use of a survey and discussions with our faculty, we identified three major practices that should be embraced for in-person or blended classrooms. Instructors can use digital chalkboards to present their lesson materials as well as see what their students are doing via screen sharing. Instructors can facilitate remote participation and collaboration to improve their in-class and outside-of-class interactions with students as well as to leverage prominent experts and improve accessibility. Finally, instructors can employ a paperless classroom to provide persistent, readily-available submission, testing, and feedback vectors for students. Embracing and integrating these best practices post-crisis will improve the overall experience for the student and the teacher, thereby allowing us truly to bounce forward from COVID in higher education.

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