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Implementing Digital Learning to Enhance Post-Pandemic Civil Engineering Teaching

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Abstract:

Civil engineering education needs to be adapted to accommodate the technological innovations and promote a culture of innovation. Future civil engineers should learn new knowledge and skill to use the emerging technologies, such as online learning tools, smart devices, remote control technology and so on. Current research suggests that replacing the traditional lecture-type instruction with interactive technological tools may enhance students' learning. The rapid transition to online learning during the COVID-19 lockdown triggered a boost of technology adoption among higher education instructors. For more than two years into the pandemic, the effect of digital learning on higher education has been remarkably profound. We are going through a change that has not happened for decades in traditional classrooms and a new digital world is forming. The pandemic has dramatically accelerated the adoption of digitized learning modes, such as live-streaming videos, recorded videos, video conferences, screen sharing, 3D graphics, online chatting, cloud file storage and transfer. Both instructors and students are getting used to technology adoption in the classroom instruction. The advantages of technology use in teaching, such as time flexibility, accessibility and convenience, are evident. As we expect a light at the end of tunnel for the pandemic, it is of tremendous interest to know how digital learning will impact post-pandemic classroom instruction.

In this paper, the effect of digital learning on civil engineering classroom instructions during the pandemic time are studied, and surveys were conducted in three civil engineering courses over the four consecutive semesters from Spring 2020 to Fall 2021, and the quantitative survey results are analyzed and compared. Effective strategies to improve the post-pandemic civil engineering classroom instructions are proposed according to the survey results and classroom observations. The digital learning approaches are proven very effective and preferred by the students and the instructors to supplement the in-person lectures.

Keywords: digital learning, pandemic, civil engineering

1. Introduction and Background:

Future civil engineers will serve as master builders, environmental stewards, innovators and integrators, managers of risk and uncertainty, and leaders in shaping public policy [1]. With the rapid growth of technologies and advancements in the world, the civil engineering profession has been in the early stages of disruption from technologies including internet and technological autonomy. To bridge the gap of the disruptors, civil engineering education needs to be adapted to accommodate the technological innovations and promote a culture of innovation. Future civil engineers should learn new knowledge and skill to use the emerging technologies, such as smart devices, automated data collection and analysis, virtual reality, and etc. Current research suggests that replacing the traditional lecture-type instruction with interactive technological tools may enhance students' learning [4].

Tracing back to the 1990s, the classroom instruction was heavily relied on blackboards/white boards and chalks/markers, and the students spent most of the class time taking notes and digested the class materials asynchronously after class. The PowerPoint presentation gained its popularity in the decade of 2000-2010, and the visual appealing slides and the downloadable electronic files freed some of students' class time for better classroom interaction and thinking. Smart devices emerged into classroom instruction in the 2010s. The pioneering work of smart device use in teaching included tablets, screencasts, clickers, pre-recorded videos and interactive social media, and most of these pilot classroom innovations were combined with the flipped classroom approach [4, 6, 7, 10, 11, 14, 17]. The fast growth of technology in the last decade has laid the ground for digitized learning and make the implementation of online teaching possible at the sudden outbreak of the pandemic [2, 3].

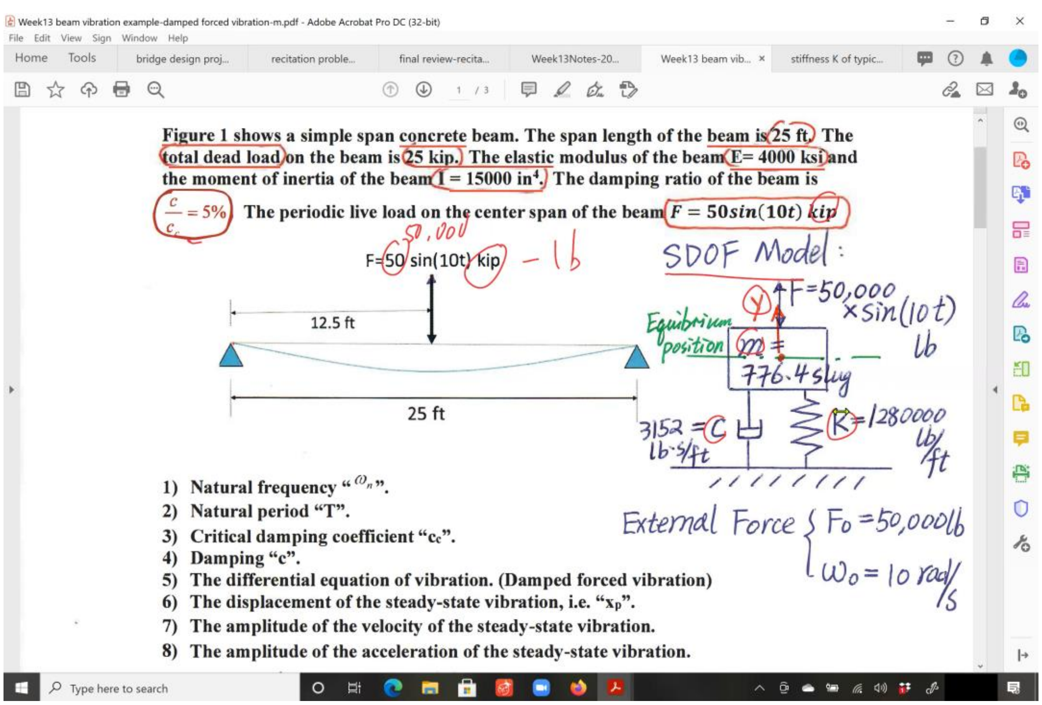

Figure 1: Synchronous Zoom Lecture during the COVID-19 Lockdown

The rapid transition to online learning during the COVID-19 lockdown in March 2020 triggered a boost of technology adoption among higher education instructors. Figure 1 shows an online Zoom lecture with the instructor's shared screen. The pandemic has dramatically accelerated the adoption of digitized learning modes, such as live- streaming videos, recorded videos, video conferences, screen sharing, 3D graphics, online chatting, cloud file storage and transfer. For more than two years into the pandemic, the effect of digital learning on higher education has been remarkably profound. We are going through a change that has not happened for decades in traditional classrooms and a new digital world is forming [2, 3, 8, 15]. Now both the instructors and the students feel comfortable to adopt technology in the classroom instruction, and the advantages of technology use in teaching, such as time flexibility, accessibility and convenience, are evident. It is of tremendous interest to know how digital learning will reshape future higher education. In this study, the surveys had been conducted for four consecutive semesters from Spring 2020 to Fall 2021, and the survey results are analyzed and compared. The impact of digital learning and the strategies of improving post- pandemic classroom instructions are discussed according to the survey results.

2. Surveys and Results:

In March 2020, feedback from the students before the COVID-19 lockdown showed they preferred the synchronous live streaming lectures much more than the asynchronous modes. The most favorable course delivery mode during the COVID-19 lockdown period was using a tablet computer for synchronous online teaching and sharing the instructor's screen with the real-time instruction materials and live notes throughout the Zoom video lectures. The live streaming lectures were recorded and saved, and the recorded lectures and class notes markups were posted on the online platform for students' reference after each lecture. A survey was conducted in one civil engineering course "CVET-437 Principles of Dynamics" at the end of the Spring semester of 2020 to collect students' feedback about the learning experience during the COVID-19 lockdown [2]. The students were allowed to select multiple answers in the survey questions if they apply.

The course delivery modes in the Academic Year 2020-2021 were in-person, blended and online. The most favorable course delivery mode during the AY 2020-2021 from the students' perspective was "blended", however, "blended" was identified as the least favorable course delivery mode by the instructors because it was difficult to jungle multiple teaching needs from the in-person and the online students simultaneously, such as writing class notes, interacting with in-person students, live-streaming lectures, using microphones, recording lectures, answering questions from online chat and so on, while teaching with a face mask and other classroom restrictions related to the pandemic. During this year, students had gradually showed the Zoom fatigue, and the number of students on synchronous Zoom had decreased along the time. More and more students had relied on online asynchronous course materials. Teamwork was challenging in the AY 2020-2021 due to the hybrid teaching modes, the quarantine requirements and the uncertainties related to the pandemic. The course delivery mode of CVET-431 in Fall 2020 was "blended", which was taught in-person in an auditorium with the requirements of social-distancing and live streamed through Zoom simultaneously, as shown in Figure 2. There were 32 students answered the survey questions in CVET-431 in Fall 2020. The other survey conducted in AY 2020-2021 was in Spring 2021 for the course of "CVET-437 Principles of Dynamics". CVET-437 was taught in-person and live-streamed through Zoom simultaneously in Spring 2021. There were 57 students answered the survey questions for the course of CVET-437 in Spring 2021.

Figure 2: Blended Teaching Mode in Fall 2020

The course delivery modes in the AY 2021-2022 were in-person and online. The "blended" option was no longer available in the AY 2021-2022 due to the feedback from the instructors. The most favorable course delivery mode in Fall 2021 was "in-person" from both the instructors' and the students' perspectives. Much less note-taking activities were observed in class, and more and more students relied on asynchronous course materials posted online after the lectures. In Fall 2021, an increasing trend to use asynchronous online course materials was observed and the in-person office hour visits were significantly reduced comparing with the pre-pandemic time. Over 95% of the students used electronic homework submission instead of hard copies. Both "CVET-332 Structural Analysis with STAAD" and "CVET-431 Structural Steel Design" were taught in-person in Fall 2021. There were 16 students answered the survey questions in CVET-332. The number of students replied the survey questions in CVET-431 was 35 in Fall 2021. The survey results aligned with the class observations.

Table 1 summarizes the semesters, course titles and the number of students responded to the survey questions.

Table 1: Summary of the Course Surveys

Semester	Course Title	Number of Students Answered the Survey Questions
Spring 2020	CVET-437 Principles of Dynamics	57
Fall 2020	CVET-431 Structural Steel Design	32
Spring 2021	CVET-437 Principles of Dynamics	57
Fall 2021	CVET-332 Structural Analysis	16
	CVET-431 Structural Steel Design	35

The survey results are illustrated in Figure 3 through Figure 9. Figure 3 shows the percentage of students selected the in-person lectures, the synchronous Zoom lectures, and the asynchronous option by using recorded videos and the posted class notes, respectively, from Spring 2020 to Fall 2021.

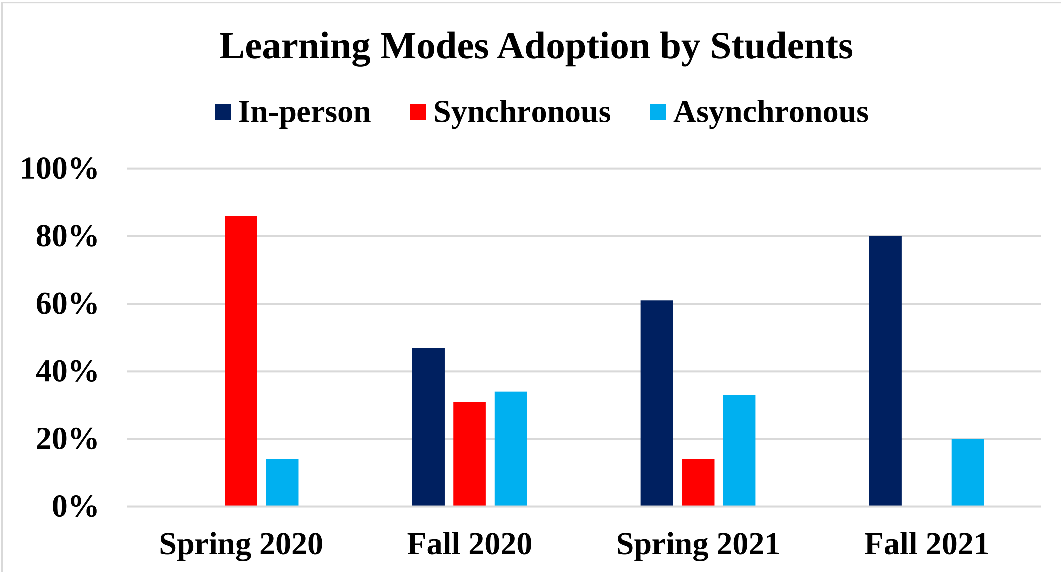

Figure 3: Learning Modes Selection by the Students

Figure 4 shows the survey results of the factors that the students considered when they chose their learning modes during the pandemic.

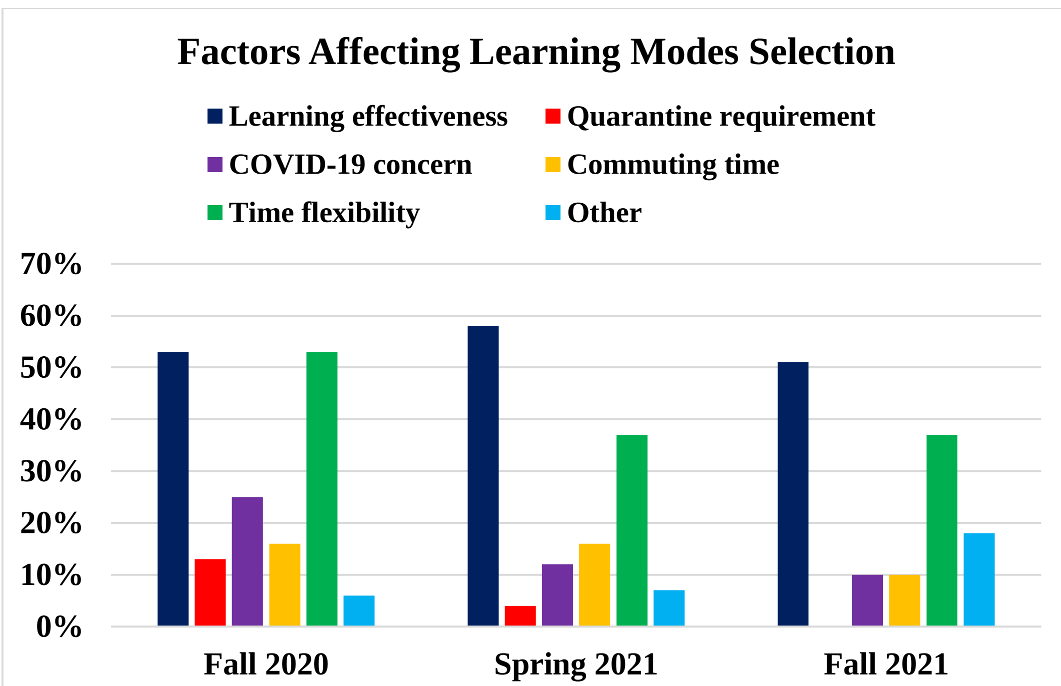

Figure 4: Factors Affecting Students' Selection of Learning Modes

Figure 5 shows the survey results of the students' feedback about their perception of the learning effectiveness by adopting the learning modes during the pandemic.

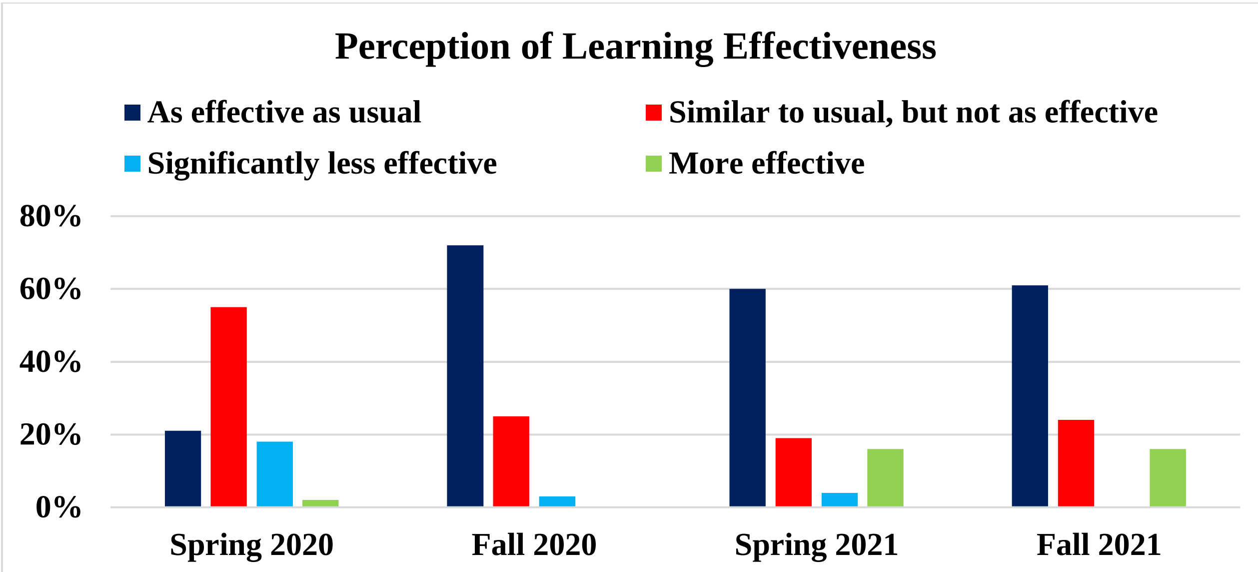

Figure 5: Students' Perception of Learning Effectiveness

Figure 6 shows the survey results of identifying the most challenging factors in learning by adopting the digital learning modes from Spring 2020 to Fall 2021.

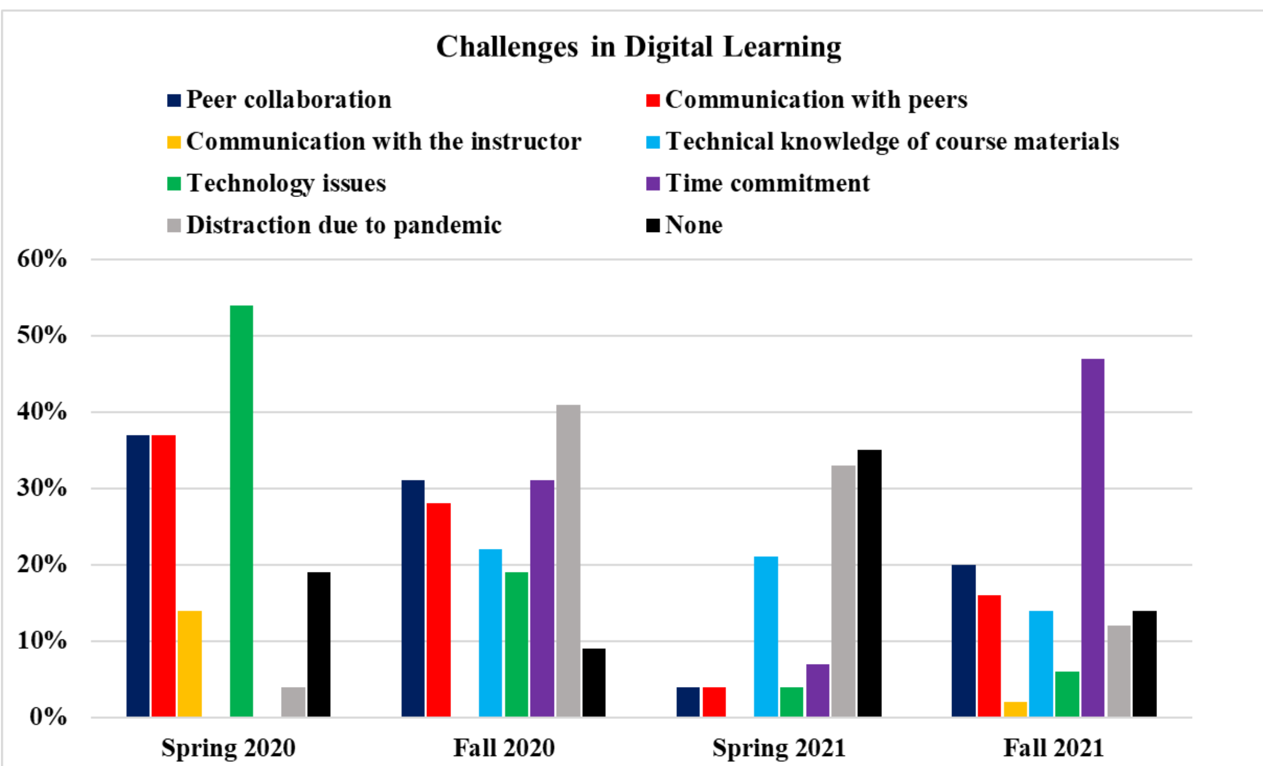

Figure 6: Challenging Factors in Digital Learning

Figure 7 shows the students' preference among the various digital forms in digital learning. We have noticed a significant increasing trend of preference in the post-processed electronic materials such as videos and class notes accompanied by declining interest in the online synchronous lectures.

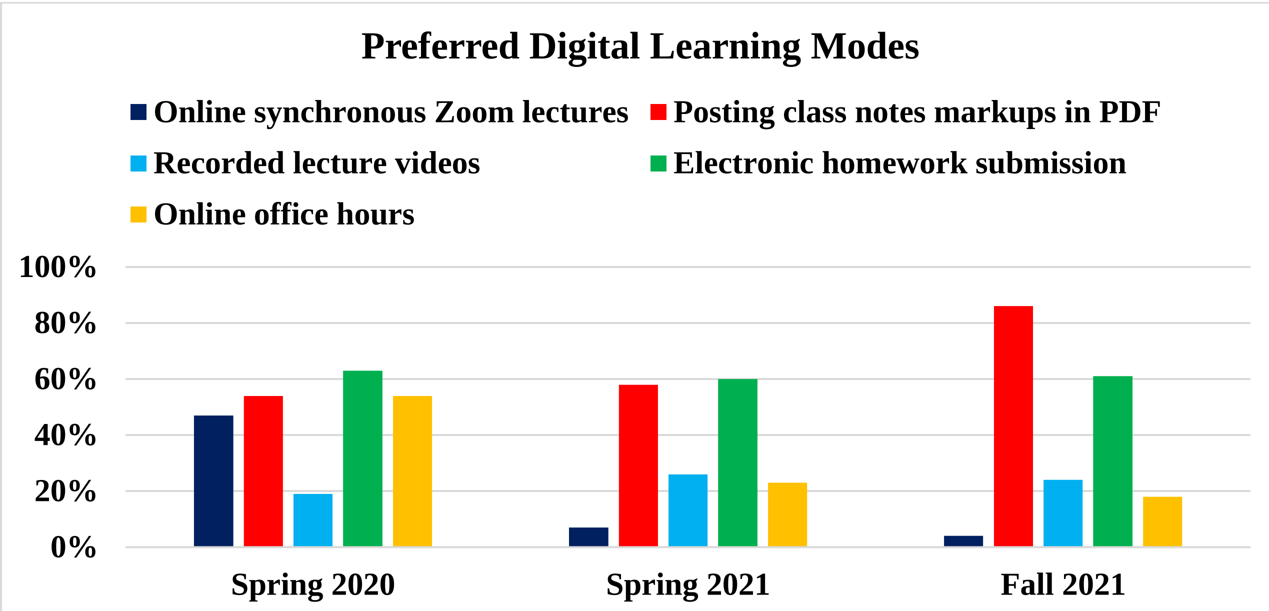

Figure 7: Survey Results of Preferred Digital Learning Modes

Figure 8 illustrates the percentage of students who used emails, text messages, social media and Zoom video conferences to collaborate with the team members in a group project of the course CVET-431 in Fall 2020 and Fall 2021, respectively. Students could choose more than one channel if it applies. The percentage showed in Figure 8 was calculated using the total number of replies divided by the total number of students.

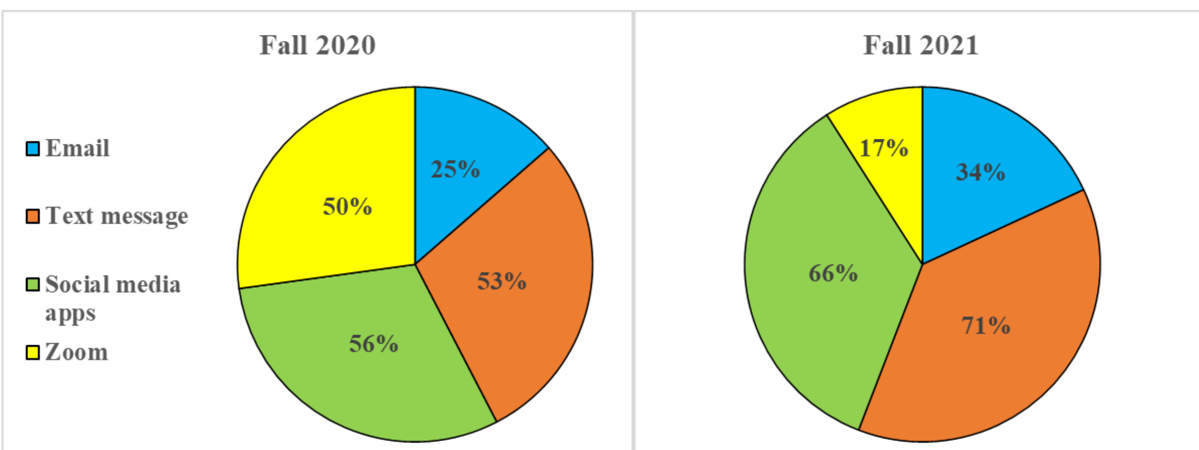

Figure 8: Teamwork Communication Channel Adoption

Figure 9 shows the percentage of students who prefer the short-clipped instruction videos of class examples versus the percentage of students who prefer the entire recorded lectures. The majority of students prefer the short version of instruction videos.

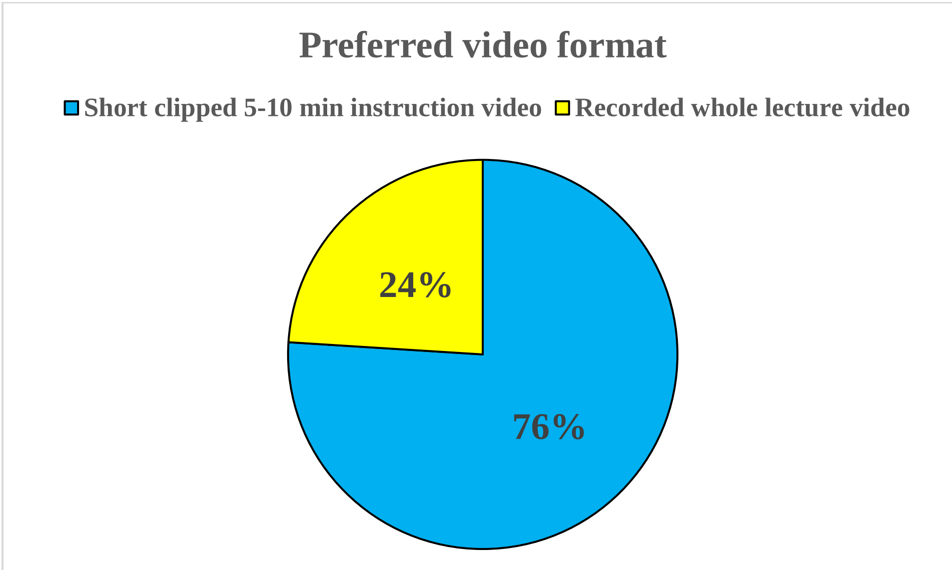

Figure 9: Preferred Instruction Video Format

3. Discussions:

Implementation of different learning styles is critical to educate engineering students, and computer-assisted instruction provides the opportunities for students to do something active besides transcribing notes [4, 5, 9, 12, 16]. The survey results show that the downloadable digital learning materials are effective to improve the students' learning. The pandemic has accelerated the adoption of the digital technologies in teaching and the classroom practices during the pandemic have proved that while digital learning could not fully replace the in-person learning environment, it could supplement the in-person learning and enhance the learning effectiveness. The digital learning approaches to supplement the traditional lectures will enhance the post-pandemic teaching.

According to the survey results and classroom observations during the pandemic, the following digital learning approaches are recommended for post-pandemic teaching in civil engineering classes:

1) For calculation-based class examples, create concise 5 to 10 minutes clipped videos or screencasts of the step-by-step problem-solving procedure. Long original class videos with an instructor occupying the video screens and extra writing time should be avoided.
2) For computer software instruction, screencast tutorials combined with step-by-step input interface screenshot instruction documents have been proven to be very effective.
3) For hands-on labs, in-person lab instructions led by an instructor combined with pre-recorded lab instruction videos are recommended.

4) Students prefer to have the follow-up course materials accessible online after the lectures, such as class notes markups, class example solutions and recorded lecture videos.
5) Electronic homework submission and online synchronous office hours are appealing to the students due to the convenience and commuting time-saving.
6) Using Zoom to live stream lectures or pre-record lectures when you travel, for example, to attend an out-of-town conference or a business meeting, to avoid cancelling classes.
7) Adopting social media platforms and smart phone apps into teaching to promote peer collaborations and communications.

The benefits and the challenges of digital learning from both instructors' and students' perspectives are listed in Table 2.

Table 2: Benefits and Challenges of Digital Learning Adoption

	Instructors' Perspective	Students' Perspective
Benefits	• Time flexibility and in-person presence independence • Options to use hybrid teaching modes if necessary • Promoting to use more visual aids in course materials • Creation of reusable digital learning materials • Creation of more outside classroom interaction channels with students • Reducing hard copies handouts • Reducing teaching interruptions due to travel and unexpected situations	• Time flexibility in learning • Easier access to digital learning materials • Free of note-taking time in class • More outside classroom interaction channels with instructors • Reducing travel time for office hours • Convenience of online homework submission
Challenges	• Dealing with unexpected technical issues • Extra effort in preparing digital learning materials, and this can be time consuming • Sensitivity to internet connections • Requiring extra technical support • In-person class attendance and participation	• Difficulty in peer collaboration • Distractions in non-traditional learning environments • Dealing with technical issues of hardware and software • Sensitivity to internet connections • Focus time duration • Video fatigue

4. Conclusions:

The rapid transition to online learning in March 2020 accelerated the technology adoption among higher education instructors, and the effect of digital learning on engineering class instruction has been remarkably profound. According to the survey results of three civil engineering courses over four consecutive semesters during the COVID-19 pandemic, we can draw the following conclusions and provide some guidance to enhance the post-pandemic civil engineering teaching:

1) In-person course delivery modes are very valuable to students' learning, and could not be fully replaced by online teaching.
2) The digital learning tools are effective to supplement the traditional lecture-type classes and enhance students' learning effectiveness.
3) Students have developed the Zoom fatigue over the pandemic time. More and more students prefer to use asynchronous online course materials to supplement in-person lectures.
4) It is important to make the follow-up digital course materials, such as class notes markups, class example solutions and short instruction videos, accessible online after each lecture. These downloadable documents can significantly improve students' learning.
5) It is very effective to use social media and smart apps to engage students' peer collaboration for teamwork and group projects.

The conclusions are based on the survey results and class observations from the author's home institution.

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