Challenges in Virtual Instruction and Student Assessment during the COVID-19 Pandemic

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Abstract

Most universities stopped face-to-face instruction in March 2020 due to the COVID-19 pandemic and completed the spring 2020 semester through online instruction and assessment. The online courses continued in summer 2020, fall 2020, and spring 2021 semesters. Rapid transition to online courses posed challenges for both students and instructors. Some students lacked access to high-speed internet and had unstable internet connection during lectures and exams. A significant challenge for instructors has been to engage students in online activities and maintain academic integrity. This paper analyzes the challenges faced by students and instructors during the COVID-19 pandemic and the approaches adopted to overcome them. The paper describes alternative methods used to assess student learning and the use of online proctored exams.

Introduction

In the late 2019, the news media reported the appearance of a novel Coronavirus (COVID-19) in Wuhan, China. In January 9th of 2019, the World Health Organization announced the discovery of COVID-19, and by January 21th the U.S. Centers for Disease Control and Prevention confirmed the first case of COVID-19 in the United States. By mid-March, most universities and colleges in the United States stopped face-to-face instructions. On March 12, 2020, The University of Texas at San Antonio (UTSA) suspended face-to-face instructions until further notice. The spring break was extended for one week to allow the faculty to prepare for online instruction. The instructors were given the choice of offering live online lectures or recording their lectures and making them available to students. For live online lectures, instructors were asked to record their lectures and make them available to students to account for cases in which students lost internet connectivity or could not attend the session(s) due to uncontrollable factors. The College of Engineering coordinated with the technical staff of the office of information technology to build a support structure for faculty members not experienced with online courses. Instructors were requested to revise their course syllabi and provide students with updated instructions related to participation, assignments deadlines, rescheduled exams, and established options for replacement of in-class exams and quizzes. The initial plan was to allow the institution to develop safe methods of instruction, so that the students, faculty, and staff can resume operation on campus. However, due to the rapid spread of COVID-19 and the sharp increase in the number of infections, the university abandoned the plan for resuming face-to-face instruction for the second half of the spring 2020 semester.

The online instruction continued at UTSA in summer 2020 and fall 2020, as well as spring 2021. However, the university modified the policies for delivering online instruction and the associated teaching modalities. The greatest challenge for the faculty is maintaining academic integrity. This paper describes the approaches adopted for delivery of live online lectures, and the tools and methods used for conducting exams. It provides a summary of the lessons learned and the modifications made to improve online instruction.
Tools for Online Instructions

Prior to delivering courses online, most instructors used Blackboard (Bb) Learning Management System [1] to provide course documents and supplementary materials to students. Typically, most instructors posted the course syllabus, copies of solutions to homework assignments, quizzes, and exams, and announcements on Bb. Bb was also used for grade reporting. In some courses, Bb was used as a tool for discussion among the students and the instructor, as it incorporates a number of secondary features to enhance the learning experience and pedagogy. Bb was also used to send email messages to entire class, or the individual students. Instructors who taught online courses used Blackboard Collaborate Ultra (BCU) for live online lectures and for recording lectures. However, different approaches for live online lectures and recording have been considered; e.g., one of the authors of this paper [2, 3] has been recoding his lectures on YouTube and providing them to public for several years. Additional web-conferencing tools with no time limit were made available to the instructors to facilitate online instructions. These included Webex [4], Zoom [5], and Microsoft Teams [6] web-conferencing platforms. The functionality of Webex and Zoom is very similar, but at the time, there were concerns about the privacy and security of Zoom. During the extended spring break period, the university asked the instructors to select one of the web-conferencing platforms and use it for their online lectures. Instructors were given the choice of either pre-record their lectures and make them available to students without meeting synchronously on the original scheduled class time, or deliver live online lectures during the original scheduled class time, but record the lectures and make them available to students. The University also asked the instructors to revise their course syllabus and make necessary adjustments to the course requirements and policies to address the hardship students were facing due to the direct and side effects of the pandemic. Adjustments to course policies and requirements included replacing exams with projects, rescheduling mid-term exam times, submission methods for exams and quizzes, and providing alternatives to situations in which students could not take online exams due to unstable internet connectivity or other technical or non-technical issues.

One of the courses that one of the authors (Instructor A) typically teaches is the undergraduate course in Measurements and Instrumentation (ME 3113). This course has an average enrollment of 90 students per semester. The course was taught by the same author during spring 2020 (50% face-to-face, and 50% online), summer 2020 (100% online), fall 2020 (100% online), and spring 2021 (100% online). The course has a lecture component that comprises 60% of the course (two individual midterm exams and eight individual homework assignments are considered as evaluation methods), and a laboratory component that comprises the remaining 40% of the course (five team laboratory assignments and one individual laboratory assignment are considered as evaluation methods). Prior to the COVID-19 pandemic, both components were taught in a face-to-face environment with the help of Teaching Assistants (TAs). The course depended on multiple contents that were digitized before the pandemic started, therefore, the transition to online instruction was not challenging for the lecture component, but the laboratory component was significantly impacted, as the hands-on component could not be replaced for most laboratory activities due to the inaccessibility to laboratory equipment.

The instructor and the TAs decided to use BCU for online instruction. Access to the BCU platform was free of charge for both instructors and students. The most important features of the BCU platform include: (1) recording of live online lecture and laboratory sessions; (2) using microphone and webcam to communicate and to display course materials in real time with students; (3) real-time
performance assessment options including multiple-choice questions, white digital blackboards that can simultaneously be used by students and instructors, and a chat; (4) easy distribution of files (e.g., assignments and presentation materials); and (5) recording of attendance, collection of students responses to multiple-choice questions, and log of chat messages posted during live online sessions. The first challenge faced by the instructor and TAs was to inform students about the BCU platform and how to properly use it to ensure an effective learning experience. The instructor pre-recorded training videos that helped students understand the methodology for instruction and the modes of performance assessment. All instructional videos were posted before classes resumed after spring break of 2020. According to students’ evaluations, the transition to online lecturing was effective, as they felt connected with the class contents, similar to the face-to-face environment. Electronic materials and recorded lectures were systematically uploaded to Blackboard, and students that could not attend the live online sessions on the original pre-established days and times were able to keep in track with the class. These materials also proved effective for developing assignments and studying before major examinations. In general, the policies related to the lecture component did not change after the pandemic began. The main change was related to attendance to live online sessions, as many students struggled to work with stable internet connection during the spring 2020 semester. Consequently, the original mandatory attendance policy was removed. However, a reduction of approximately 30% on attendance was observed during the first two months of instruction. Investigations revealed that students had to adapt to their specific situations and continue learning at different times. Thus, the recording of the lectures proved not only effective for learning enhancement but also necessary to enable students to learn the course materials considering the non-controllable technical and non-technical limitations.

The instruction of the laboratory component followed the same philosophy as in the lecture component, with live sessions that were recorded and later shared with students. However, the laboratory component was affected in a significant way, as students did not have access to the equipment used to complete assignments. Consequently, the instructor and TAs decided to pre-record the experimental procedures needed to complete laboratory work, and provided students with the experimental data to be analyzed by them. Students worked collaboratively using BCU and other third-party communication platforms, and submitted professional reports compliant with the American Society of Mechanical Engineers (ASME) standards. The instructors were satisfied with the quality of the work done by students, as these activities helped students conducting experiments outside the laboratory environment. All laboratory assignments were modified in such a way that the activities always had a relevance to the course objectives and provided students adequate learning experience. In an effort to integrate hands-on work as part of the laboratory component, the instructor did a thorough investigation for inexpensive components and materials that could be safely delivered to the students’ homes. Such components included sensors, actuators, and data acquisition systems that, when properly integrated using the theory covered in the lecture and laboratory sessions, could mimic the operation of the more complex and expensive equipment located in the laboratory. The instructor-vendor interactions led to the creation of inexpensive educational kits with a net cost ranging between $20 and $40. Kits were purchased with the support of the Mechanical Engineering department and were sent to the students’ homes. Then, students were tasked with designing, assembling, and operating a generalized measurement system, similar to the ones available in the laboratory. Thereby, students were able to conduct experiments at home, attained the main objective of the laboratory assignment, and orally presented their results through BCU. Students were allowed to keep the educational kits for use in other upper-division courses.
Another author (Instructor B) taught a required undergraduate course in Thermodynamics (ME 4293) with an enrollment of 92 students, as well as a graduate course in Advanced Thermodynamics (ME 5243) with an enrollment of 15 students in spring 2020. This instructor taught an undergraduate course in Heat Transfer with an enrollment of 101 students in fall 2020. In spring 2021, instructor B is again teaching an undergraduate course in Applied Thermodynamics with an enrollment of 42 students and a graduate course in Advanced Thermodynamics with an enrollment of 22 students. A design project is included in both undergraduate courses in Thermodynamics and Heat Transfer courses, having a weight of 10% on the final grade. Homework assignments have a weight of 10% and student’s performance in exams and quizzes account for 80% of the final grade. For the graduate course, the homework assignments have a weight of 20%, a research project has a weight of 10%, and exams count for the remaining 70% of the grade. Prior to the transition to online instruction, the instructor used a combination of power-point presentation of figures and equations and writing on black/white board for the delivery of the lectures. The figures and general equations were projected on classroom screen to save time, while derivation of equations and example problems were presented on the board. Later, the instructor added the solution to the example problems solved in class to the power-point presentation slides and posted them on Bb. After the transition to online teaching, the instructor added the hand written derivation of formulas and solutions to example problems to power-point presentations in advance and went through them slowly for student comprehension during virtual lectures. The power-point pen function was used to add additional notes to the slides during the lectures. The instructor employed Webex platform for delivery of lectures, office hours, and recitations. The virtual lectures were recorded and both the power-point presentation and the recording of the lectures were made available to students on Bd. The biggest challenge was writing equations or showing solution steps when responding to students during the virtual lectures or office hours. Originally, the pen function of power-point presentation was used to provide written answers to questions. Later an external Webcam was used to provide written answers. As shown in Fig. 1, the webcam was attached to a stand allowing the instructor to write the answers on white paper using the Webex video function. Alternatively, a Tablet can be used in providing written answers to students’ questions.

Another author (Instructor C) taught an undergraduate technical elective course in thermal systems design (ME 4323) in spring 2020, with enrollment of 45 students. This instructor taught both required undergraduate courses in thermodynamics in fall 2020. The first course in thermodynamics (ME 3293) had an enrollment of 143 and the second course in Thermodynamics (ME 4293) had an enrollment of 131 students. In spring 2021, this instructor is again teaching the undergraduate technical elective course in thermal systems design, with an enrollment of 37 students. For both thermodynamics courses, the homework assignments had a weight of 10% and three exams accounted for the remaining 90% of the course grade. For the technical elective course, homework assignments had a weight of 20% and two exams counted for the remaining 80% of the course grade. After the transition to online teaching, the instructor used the BCU platform to deliver lectures and Bb for exams. In fall 2020, the instructor used a hybrid model to teach the two thermodynamics courses. In this case, the lectures were pre-recorded outside the scheduled class time. However, exams were conducted online at pre-scheduled class days and times. In spring 2021, the instructor is teaching the course online on scheduled days and times, without requiring students to attend the live virtual lectures. The recorded lectures are made available to students shortly after the end of the live online instruction. Exams are conducted online during pre-scheduled days and times.
Class Modalities

In spring 2021, the university defined various types of teaching modalities, different to the ones considered in spring, summer and fall 2020. The definition list was expanded to include the following types:

- **Face to Face**: Traditional in-person course that meets at the scheduled time and location.
- **Hybrid 1/3**: Traditional courses that meet three days per week. One of the three days, it meets in-person and remainder is asynchronous online.
- **Hybrid 2/3**: Traditional courses that meet three days per week. The course meets two of the three days in-person and remainder is asynchronous online.
- **Hybrid 1/2**: Traditional courses that meet two days per week. One of the two days, it meets in-person and remainder is asynchronous online.
- **Online Synchronous**: Course meets fully online and all meetings are at the scheduled time.
- **Online Asynchronous**: Course is fully online without any scheduled meeting times.
- **Online Hybrid 1/2**: Traditional courses that meet two days per week. Course is offered fully online. It meets at the scheduled time on one of the two days and remainder is asynchronous online.

In fall 2020 and spring 2021, the university only allowed online asynchronous and online hybrid classes, with a few exceptions. The Measurements and Instrumentation course taught by instructor A was scheduled as an online asynchronous mode, with lecture sessions, laboratory sessions, and exams conducted virtually at pre-established days and times. Instructor B’s classes were also scheduled as online asynchronous in fall 2020 and spring 2021, meeting online on pre-scheduled days and times. All exams were conducted on scheduled days and times. Instructor C used the
Hybrid 1/3 modality for thermodynamics classes in fall 2020. All lectures were recorded and made available to students, and online meetings were designed for question/answer sessions with the instructor having prepared short true/false or multiple-choice questions to promote discussion. The online sessions were at specific times/days of the week. No grades were recorded from the live online sessions and as a result, many students ignored them. Online exams were conducted on pre-scheduled times and dates. The instructor is using the online synchronous modality in spring 2021, where virtual lectures are given and recorded on regularly scheduled class times and online exams are scheduled within a 24-hour window to take the exam, so students have flexibility in taking the exam. The potential drawback is that students can share information using GroupMe, Discord or similar communication apps, which are used by many students.

**Assignments**

In the courses that the three authors have been teaching since spring 2020, assignments included homework problems, laboratory and project reports, and quizzes. Instructors B and C assigned Wiley-Plus [7] problems in their undergraduate thermodynamics and heat transfer courses. Wiley-Plus assignments use randomized parameters in problem statements such that the correct numerical answers are not the same for all students, and they can differ from the numerical answers presented in the textbook solution manual. The advantages of these type of assignments are: (1) the assignments are graded automatically, (2) students get immediate feedback on their solutions, and (3) due to randomization, students have to put extra effort in solving these problems instead of simply copying from a solution manual. The instructor can set the system in such a way to allow students multiple attempts, often with minimal grade penalty for multiple attempts. This provides additional opportunity for student to learn the course material. Instructor B also requires students to submit detail solutions of Wiley–Plus problems for extra credit. Since the Wiley-Plus problem has been already graded, the handwritten solutions are not graded for correctness but are graded for originality, clarity, organization and completeness. At times, Wiley-Plus solutions are incorrect for some of the randomized problems, which is very frustrating for students. In those cases, the handwritten solutions are used to check students’ solutions in order to make appropriate adjustments to assignment grades. Instructor B assigns design project in the undergraduate Applied thermodynamics and heat transfer courses. He also assigns a research project in his graduate thermodynamics course. Prior to the COVID-19 pandemic, the instructor assigned group projects [8]. After going online, simpler individual projects were assigned to maintain the social distancing requirements.

**Exams**

In fall 2020 all three instructors proctored their first midterm exam in person on campus. All three instructors have been using Gradescope [9] to grade exams. This grading system allows a team of TAs and/or instructor(s) to work simultaneously to grade different problems of the exam without having to shuffle exams. After going online, students submitted the PDF scanned copies of all assignments, including exams, through Gradescope, and graded materials returned to students through the same platform.

Assessing student knowledge has been a major challenge during the pandemic. A sharp increase in cheating was detected in recent years [10-13]. Scholastic dishonesty includes copying solution
manuals for homework assignments, using phones, text, and apps to share answers; using phones to take images of exam questions, sending them to external tutoring services, and copying solutions received from the external tutoring services. Some of the department faculty members have identified such cheating methods and have penalized students who had copied solutions received from such tutoring services (e.g., Chegg [14]).

During spring 2020, Instructor A decided to replace the midterm exam by a project that integrated all the concepts covered during the first half of the semester. However, after projects were turned in, the instructor and TAs detected substantial plagiarism. Information and solutions were copied from third-party online tutoring services not related to the university. Investigations resulted in several academic dishonesty proceedings against those students who violated critical course policies. In response to the growing concerns related to academic integrity, the instructor decided to use Blackboard as a mechanism to deliver non-proctored exams. The exams consisted of quantitative problems that were randomized in two forms: (1) the order of appearance of problems (with no backtracking allowed), and (2) the parameter values in each problem. In addition, the exams were conducted on scheduled days and times. Before exams, a special live session was conducted to review the policies and procedures for taking the exams. Despite the efforts in designing exams that reduced the possibility of cheating, scholastic dishonesty was still discovered through the analysis of students’ responses and information obtained from online searches, which resulted in academic dishonesty cases filed against students who violated the exam policies. The identification of academic dishonesty was effective as exams were unique among students due to randomization of parameters in exam problems. However, randomization also resulted in a very complex process for grading, as each exam was fundamentally different, and in some cases the solution procedures changed depending on the parameter values. The development of a uniform rubric for grading exams was more challenging, as it required developing a solution for each randomized problem and then providing specific feedback to each randomized question solved by each student. This ultimately resulted in long periods required for grading the exams and providing feedback. Finally, even with randomized problems, the instructor realized that academic integrity could not be fully assessed, as it was impossible to determine what prohibited materials were used by students during the exams.

Instructor B gave the first closed book/closed notes exams in both the undergraduate and graduate courses in Thermodynamics in spring 2020 when students were still on campus. Due to the large enrolment, the undergraduate course exam was conducted in a large classroom with more than 250 seating capacity. This allowed at least one empty seat between two students. Students were required to put their cell phones in their bags and leave the bags against the classroom walls. Only the equation sheet created by the instructor, a thermodynamics property booklet, and a calculator approved for the Fundamentals of Engineering Exams (FE) [15] allowed for the exam. The first graduate course exam was given in the regularly scheduled classroom. The second midterm exams were conducted online, using the Webex platform. Students were asked to activate the video function of Webex while taking the exams. For the second exam, many students claimed that they did not have a camera on their computer, which complicated the procedures and logistics. By the time for the final exam, all students were required to use their computer camera or an external webcam during the exam.

For the second midterm exam in the undergraduate thermodynamics course, randomized reserved Wiley-Plus problems having multiple parts were used for the exam to minimize the potential for cheating. The Willey-Plus system was set in such a way that students had to answer each part of the
question in sequence, before the next part of question became visible. Students had two opportunities to respond to each part of the problem. The exam questions were posted on Bb and released to students at a specified time. Students could print the exam and solve the problems in spaces provided for each part of exams. Those who did not have a printer could solve the problems in appropriate space provided on the exam template. To reduce the potential for cheating, the exams were time limited. The thought is that a time-limited exam allows the student less time to go outside the exam and search for solutions. Students, however, were more stressed on highly time-limited exams often because they could lose time because of computer hardware/software problems. Exams in many classes gradually adopted exam proctoring software named Proctorio [16].

**Proctorio**

The university evaluated a number of software tools to proctor online exams and eventually provided the software Proctorio free to all students in all classes. Proctorio is integrated with Blackboard in such a way that exams are administered while leveraging students’ hardware, specifically their webcam and microphone. In addition, Proctorio recorded the students’ computer screen and created a log of the internet navigation during an exam.

Proctoring exams with Proctorio is significantly different to real-time proctoring. Proctorio records and stores data for each student and only the instructor has access to the data after the exam ends. Based on the analysis data, the instructor could, with sufficient time, review all of the recordings to assess academic integrity. Randomization in proctored exams was eventually removed, leading to reasonable times for grading. Proctoring exams through Proctorio application was fine-tuned as the semester progressed using students’ feedback and the instructors’ experience. At first, faculty accepted any webcam view provided, be it from a laptop located at the top of the monitor or bottom. After review, it was found students were accessing their phone during exams and the webcam did not show it. A set of policies were developed to instruct students to point their webcams to their working area, showing student’s hands, keyboard, mouse, calculator and portion of screen, and student’s body. Figure 2 shows the recommended position of an external webcam position with a flexible clamp-mounted stand.

The preferred view is with webcam located about one foot in front and a little above the student’s head. The required webcam view shows both student hands, keyboard, mouse, calculator (if allowed), papers, side of face, and side of computer monitor. Figure 3 shows a good example of webcam view.

Loose, blank, 8.5 in x 11 inch paper is required for hand calculations during the exam. Engineering, graph, lined or clean printer paper was accepted. The paper had to be loose since some students had used spiral bound paper and pad of paper to conceal notes which were hard to see on the webcam. Likewise, no paper copies of equation sheets and/or appendices were allowed since some students had previously used them to hide forbidden notes. Electronic copies of all materials were included with the exam. This improved proctoring, as it was possible to verify what items were used by students during the exam. Although this system promotes exam integrity it could not completely ensure it. From the final exam of some courses, it was clear that some students had an accomplice in the room who took pictures of the exam problems on the computer screen over the shoulder of the
student, submitted the problems to 3rd party platforms or external tutoring centers such as Chegg, then displayed the results on another screen in the room visible to the student.

Figure 2. Side view of external webcam positioned using tripod on elevated surface (left) or using flexible clamp-mounted stand attached to desk (right).

Figure 3. Good example of required webcam view showing hands, workspace, keyboard, calculator, paper, side of face, and side of monitor. Only one monitor is allowed during online exams.

The current strategy for designing, administering, and grading exams includes the following steps:

**Step 1:** The instructor creates problems on the exam based on the materials covered in the class. The number and complexity of problems is decided in such a way that the exam can be completed by the instructor in under one-half of the time scheduled for the exam.

**Step 2:** The instructor uploads an electronic copy of the exam on Bb, such that students through links to the exams can access problems, and other materials needed to complete the exam (equation sheet, property tables, etc.)

**Step 3:** The instructor defines and implements Proctorio options for the exam that could include, recording video, recording audio, recording computer screen, recording web traffic, recording room environment, allowing single computer screen only, disabling new tabs, closing all open tabs, disabling printing, disabling clipboard, and clearing cache. The
general verification prior to the start of exam includes verifying webcam video, audio, and computer’s monitor. It is recommended not to require recording of the room environment, since this function created problems for students to start the exam on time.

**Step 5:** The instructor creates a dedicated BCU/Zoom/WebEx session to be in contact with the students during the exam, in case they have questions or have technical problems. Students can ask questions in chat using public or private messages to help them resolve problems they encounter during the exams.

**Step 6:** At the end of the exam, students scan and submit a detailed solution to problems on the exam and upload them on either Bb or Gradescope. Scanning and the submission of exams usually requires less than 10 minutes. In addition, students are required to keep Proctorio active until the entire exam is submitted. Students are allowed to use a multi-function printer or a smart phone app to scan their exam solutions.

**Step 7:** The instructor receives all exams in digital form by the deadline. Exams submitted late are subject of penalties that vary depending on the number of minutes late. Best compliance was found when the late penalties are escalated with the time being late.

**Step 8:** The instructor grades the exams using either Bb or Gradescope. At first, many instructors used Bb but found it to be inconvenient. Gradescope became the preferred platform for grading exams since it is easier to use and has more flexible features than Bb. For example, a grader can modify a grading rubric in the middle of grading student exams. The graded exams are released to students through Bb or Gradescope. Students have one week after the release of each exam to request for regrade. Regrades are handled through email using Bb or Gradescope. In general, Gradescope has superior built-in grading features as compared to Bb.

The followings are examples of areas that worked well in the courses taught by all instructors. These are based on students’ feedback, and the experiences gained by the instructors and the TAs.

- Access to digital lecture notes and lecture recordings, including supplemental materials and special software.
- Proctoring exams with special software (Proctorio) enabled the instructor to maintain academic integrity in the course.
- Providing proctored practice exams (with identical settings as compared to the proctored real exam) for: (1) testing students’ software and hardware before exams, (2) allowing students to get familiar with the procedures to follow while taking exams, and (3) for students to conduct self-performance assessments. Practice exams were typically conducted one week prior to actual exams. Students received extra credit for completing practice exams.
- Gave make-up exams when technical or other acceptable non-technical issues occurred.
- Rapid response by the instructor to questions received through email. Clear communication through BCU/Zoom/Webex during lectures and laboratory sessions.
- Extended and flexible office hours. WebEx has a meeting room that students can join the lectures and office hours. Right before the start of the lectures or office hours, an email notice is sent by Webex to the instructor if one or more students are waiting in the Webex meeting room. The instructor can also schedule private Webex meetings with individual students.
- Provide electronic experimental data via email or Bb to students, in order for them to complete their laboratory assignments. This strategy proved to be effective for attaining the
learning objectives of hands-on experience without being present in the laboratory on campus.

Examples of areas that did not work well for exams:

- Substituting exams for special projects. Academic integrity is questionable, but little evidence becomes available to charge violators for scholastic dishonesty. Overall, the assessment of projects it is not considered a reliable mechanism for evaluating student learning.
- Conducting non-proctored exams. Academic integrity is questionable, but little evidence becomes available to charge violators for scholastic dishonesty. Instructors could find their exam problems posted on third-party tutoring centers (e.g., Chegg), but it was difficult to track back the posting to an individual student.
- Conducting fully randomized non-proctored exams. Academic integrity was often questioned and required significantly more time to grade and provide feedback to students.
- Allowing students to print equation sheets, tables, diagrams and figures prior to an exam. Academic integrity was compromised, as it was easy for students to hide unacceptable materials, or have annotations on the printed documents. Instead, links to digital documents provided with the exams can be proctored during exams.

Examples of aspects that still require improvement based on student’s feedback and the instructors experience:

- Development of more hands-on work for the laboratory component; not only for specific laboratory assignments.
- The use of more real-time feedback tools and active learning, or activities that deviate from traditional passive lecturing, to maintain engagement.
- Reduce the times associated to grade/return exams and assignments.
- Avoid exceeding the official lecture time, even if the lecture and laboratory sessions are recorded.
- Accommodate technical problems with Proctorio that may affect the performance of some students. The exploration of alternative proctoring tools is suggested.
- Students expressed that stress and anxiety due to being recorded during an exam affected their performance. Integration of university programs to manage stress and anxiety in the course is recommended.

Student feedback

During the last week of the fall 2020 semester, a survey was conducted in the undergraduate course in Heat Transfer to obtain students’ feedback on their experiences with the course and the online teaching. The survey contained 31 statements covering various topics, eleven (11) of which are related to the topics of discussion in this paper. Statements 1 through 4 were related to modality of course offerings during the semester and the students’ preferences. The following information was provided on the survey questionnaire:

Since March 2020, the university faculty have been presenting almost all lectures online due to COVID-19 pandemic using the following modalities:

- **Online Asynchronous**: Classes do not meet in real-time – (fully online course)
• **Online Synchronous:** Classes meet in real-time
• **Online Hybrid:** Classes meet in a mixture of real-time and not real-time; the course syllabus will indicate the frequency of the scheduled meeting times

Statements 5 through 7 asked for students’ opinion about the lectures, the power point presentations, and the recording of the course lectures during the semester. Statements 8 through 12 related to the use of Proctorio in exams. Seventy Six (76) students participated in the survey. The participants were asked to rank their agreements with each statement as (5) strongly agree, (4) agree, (3) neutral, (2) disagree, (1) strongly disagree, and (0) no answer or does not apply. Table 1 presents a summary of the survey results.

Table 1. Summary of the survey results, Heat Transfer fall 2020.

<table>
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<td>The Online Asynchronous lectures provides the best learning environment for me.</td>
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<td>2</td>
<td>The Online Synchronous lectures provides the best learning environment for me.</td>
<td>3</td>
<td>15</td>
<td>13</td>
<td>18</td>
<td>18</td>
<td>9</td>
<td>73</td>
<td>2.9</td>
</tr>
<tr>
<td>3</td>
<td>Online Hybrid lectures provides the best learning environment for me.</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td>28</td>
<td>10</td>
<td>9</td>
<td>68</td>
<td>3.0</td>
</tr>
<tr>
<td>4</td>
<td>I prefer Face to face lectures to any of the online lecture modalities.</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>12</td>
<td>13</td>
<td>42</td>
<td>76</td>
<td>4.1</td>
</tr>
<tr>
<td>5</td>
<td>In the course, attending lectures and reading textbook materials were sufficient to complete my assignment.</td>
<td>0</td>
<td>9</td>
<td>17</td>
<td>15</td>
<td>24</td>
<td>11</td>
<td>76</td>
<td>3.1</td>
</tr>
<tr>
<td>6</td>
<td>The power point lecture presentations posted on Bb was helpful in completing course assignments and prepare for exams.</td>
<td>1</td>
<td>5</td>
<td>13</td>
<td>15</td>
<td>26</td>
<td>15</td>
<td>74</td>
<td>3.4</td>
</tr>
<tr>
<td>7</td>
<td>The recorded lectures helped completing course assignments and preparing for exams.</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>28</td>
<td>23</td>
<td>11</td>
<td>75</td>
<td>3.3</td>
</tr>
<tr>
<td>8</td>
<td>Taking online exams is more stressful than exams taken in classroom.</td>
<td>0</td>
<td>6</td>
<td>3</td>
<td>20</td>
<td>7</td>
<td>40</td>
<td>76</td>
<td>3.9</td>
</tr>
<tr>
<td>9</td>
<td>Using Proctorio maintains the integrity of grades earned by students during online exams.</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>18</td>
<td>22</td>
<td>26</td>
<td>76</td>
<td>3.8</td>
</tr>
<tr>
<td>10</td>
<td>I was quite anxious the first time I took a Proctorio test.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>17</td>
<td>55</td>
<td>76</td>
<td>4.7</td>
</tr>
<tr>
<td>11</td>
<td>My anxiety has reduced as I took more and more Proctorio exam.</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>16</td>
<td>22</td>
<td>21</td>
<td>71</td>
<td>3.6</td>
</tr>
</tbody>
</table>

The results in Table 1 indicate that the majority of students prefer in person face-to-face lectures over any kind of the online course offering. The textbook, class lectures, power point presentations, and the videos of class lectures all equally contributed to student learning. The results show that the vast majority of students were quite anxious when they took the first Proctorio exam. The anxiety seems to be reduced as students gained more experience in taking Proctorio exams. The written comments about Proctorio exams were mixed. Some students were happy that Proctorio is being used to maintain the integrity of grades, while others were complaining that it makes them anxious.

Conclusions

The primary challenge that resulted from the mandatory transition to online courses caused by the COVID-19 pandemic was to maintain academic integrity and engagement with the students. Before the pandemic, a handful of students would cheat in face-to-face exams, but this problem intensified
with online exams with students sharing answers in multiple ways, including the use of 3rd party software such as GroupMe (primarily by phone) and Discord (primarily by computer). Students also sent exam problems to online tutors who reply with a solution, the most popular site being Chegg. Using online exam proctoring software, such as Proctorio, has discouraged but not eliminated cheating. Despite the faculty efforts, cheating in online course continues to be a significant problem. Based on our experiences, it is recommended that faculty:

1. use online exam proctoring software, if it is provided by the University,
2. reduce or eliminate paper materials allowed during the exam, where appendices and equation sheets should be provided electronically as part of the exam,
3. require student webcams to show their hands and workspace at all times during the exam,
4. add unique identifiable features to each exam problem in case the problem is posted/shared, so that it can be traced back to the student who was given that problem.

Many students are honest and want faculty to uphold academic integrity, yet students also want faculty to acknowledge and accommodate many of the hardships the student may face in an online class. In an online class, students are more prone to procrastination, they find it difficult to stay engaged, and are stressed because of additional hardware/software problems. Online exams are particularly stressful because of the added complexity of relying on a computer, internet, and software to take the exam. It is recommended that faculty:

1. provide highly structured courses to help students stay on-track,
2. adopt low/no-stakes quizzes to keep students engaged in online classes,
3. retain familiar instruction/assessment methods, which are effective for face-to-face, especially punctual class meetings,
4. provide practice exam so students become familiar with taking online exam before taking the real exam,
5. provide a reasonable time window to take an online exam, and
6. accommodate students who experience disruptions even when the student cannot produce evidence of the disruption, like computer/internet problems.

The last point is contradictory since some students make excuses in order to cover for their lack of preparedness on exam day. Yet faculty should be flexible to help students facing a wide-range of challenges while also being diligent to uphold the academic integrity of the course.

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5. https://zoom.us/
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