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Pandemic-Induced Impacts: Experiences in an Introductory Engineering Graphics Course

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ABSTRACT

The COVID-19 pandemic has impacted technology, engineering, and design education as well as workforce development programs worldwide. The emergency transition to fully online course delivery ushered experiences from which course restructuring could utilize. Through an illustrated case study approach using student course evaluations coupled with instructor interviews, this article reports on the experiences resulting from the abrupt interruption of the Spring 2020 semester and how the restructure of an introductory engineering graphics course accommodated changing expectations. The restructured course was built upon a hybrid flipped model utilizing an online learning management system including active learning modules which provided a foundation of preparedness for transitioning to fully online course delivery. As positive as the preparedness was, there were still changes that had to occur to not only meet the needs of the emergency situation but to also establish multiple models of the course for future situations. These changes included incorporating web conferencing software to meet online when a face-to-face meeting was not possible, developing video lectures for students to watch when most accommodating for their schedule, as well as the increased use of the online learning management system. Another change from the restructuring process was the new technology expectations of students and instructors. Feedback from both students and instructors reported how flexibility, empathy, and effective communication were driving traits of positive experiences in such an unprecedented situation. Reported experiences along with elements of the course restructuring can serve as an example of how future courses are delivered for a variety of situations.

Key Words: pandemic, course restructure, asynchronous learning, synchronous learning, active learning modules

INTRODUCTION

Resulting from the unprecedented outbreak of COVID-19 was a declaration of national emergency on March 13th which led to campuses across the country swiftly closing and therefore transitioning technology education courses to online delivery (Gaudiot & Kasahara, 2020).

Not only universities and schools closed but also major businesses and organizations around the world ceased in-person working environments and transitioned to fully online (Donthu & Gustafsson, 2020; Gaudiot & Kasahara, 2020; Petillion & McNeil, 2020). Amid the influenza pandemic of 1918, schools in many areas of America had to close for as long as 15 weeks (Stern, Cetron, & Markel 2009). During this time, it was not possible to hold classes online so schools mailed assignments to homes, postponed courses, or completely canceled courses (Stern et al., 2009; Thomas & Foster, 2020). Over a hundred years later, courses were able to transition from face-to-face or hybrid format to an entirely online environment with the onset of COVID-19 (Gaudiot & Kasahara, 2020; Petillion & McNeil, 2020). However, this transition was sudden and instructors of varying levels of technology education courses as well as workforce development programs around the world had to abruptly alter their course structures and instructional methods.

One impacted course was an introductory engineering graphics course at a large land-grant university in the southeastern United States where students learn about the foundational elements of engineering graphics such as visualization and sketching. The fundamentals focused within the course are the ability to design, document, and communicate using engineering graphics. Course content is integral to engineering and design because sketching provides the ability for designers to understand ill-defined problems, improve problem-solving applications, improve spatial ability, and clearly communicate technical details. (Booth, Taborda, Romani, & Reid, 2016; Kelly & Kelly, 2020; Marunic & Glazar, 2012). Content from this course applies to technology education curricula as well as individuals pursuing engineering degrees (International Technology and Engineering Educators Association [ITEEA], 2019; Meyers, 2000). Since the course is a requirement for engineering degree programs as well as the technology, engineering, and design education program, the sudden transition impacted 395 students enrolled in the course (six sections of 60 students and one section of 35 students). Engineering graphics courses

establish a foundational skill set for engineers as well as technology educators (Ernst, Clark, & Kelly 2019). Sudden alterations in course delivery, in addition to the societal tensions related to a global pandemic, represent stressful situations that can lead to negative impacts on academic performance, motivation, and engagement in course-related, foundational skills (Pascoe, Hetrick, & Parker, 2020). Further, challenges associated with an abrupt change in course delivery included issues with motivation and engagement, personal scheduling, faculty communication, and increased stress and anxiety (Petillion & McNeil, 2020).

This article evaluates the changes that occurred in the introductory engineering graphics course as a result of the global pandemic and expresses the experiences of students as well as instructors. The research questions focused on during this case study include the following:

RQ1: How has the sudden transformation of the education environment due to the COVID-19 pandemic impacted introductory engineering graphics course delivery?

RQ2: How has the sudden transformation of the education environment due to the COVID-19 pandemic impacted the perceptions of the introductory engineering graphics course delivery?

RQ3: What were the instructor experiences resulting from the structural changes of the introductory engineering graphics course?

RQ4: How did students react to the changes implemented in the introductory engineering graphics course?

COURSE STRUCTURE CHANGE

The introductory engineering graphics course is described from the course syllabus as an introductory course providing orientation to the language of technical graphics for students majoring in any field. The course is designed to help students develop and refine their ability to use this universal technical language within the context of the concurrent engineering design process as well as gain an understanding of how computer-aided design (CAD) is used to create solid model objects that students use on a daily basis. Prior to the outbreak, the course implemented a hybrid model consisting of online lessons and active learning modules where students attended in-person lectures and completed assignments online. Online

active learning modules acted as a stand-alone, web-based learning supplement used as a tool to reinforce curriculum and increase retention as well as persistence in engineering programs (Ernst et al., 2019; Kelly, Clark, & Ernst, 2019).

On March 11th, 2020, the announcement was made that all university courses would go online until further notice. This occurred 10 weeks into the 17-week semester and ultimately remained the plan for the remainder of the spring 2020 semester. Challenges from this time included students having varying levels of experience in engineering graphics accompanying their need for provided support from instructors to meet these various levels. From the experiences of the spring 2020 semester, the course was restructured to provide multiple possible course delivery options which accommodated the possibility that the majority of courses for the fall 2020 semester would remain online until further notice.

During the restructuring process, instructors responsible for the course revamp wanted to target two goals. The first goal was the availability of multiple course models (face-to-face, hybrid flipped, and online) to simplify facilitation and accommodate course delivery requirements for any given situation. The second goal was to accommodate the demand for teaching large sections of students (up to 60 students per section) during and after the COVID-19 pandemic. Ultimately, as a result of the risks associated with meeting in-person during the course hybrid model, fall courses were moved to a fully online environment where instructors had the option of synchronous or asynchronous course delivery. Synchronous course delivery entails each unit being opened by the course instructor and a weekly scheduled online lecture being held (Oztok, Zingaro, Brett, & Hewitt, 2013). Asynchronous course delivery involves students moving through course components at their own pace where the next unit would become available once the student successfully completed each unit (Oztok et al., 2013).

Online course elements from the restructure for both asynchronous and synchronous models included content resources, portable document format (PDF) copies of content presentations, videos of content lectures, assignments submission, assessments, active learning modules, as well as CAD solid modeling practice. Figure 1. is an example of one of the lessons laid out in the online learning management system. When applying the online

■ ORIENTATION

■ Lesson 1a- Introduction to Engineering Graphics Communication

■ Lesson 1b- Constraint-Based Modeling Basics

■ Lesson 2- Sketching Classifications

■ Lesson 3- Engineering Geometry

■ Lesson 4a- Production Theory 1: Basic Pictorals

■ Lesson 4b- Production Theory 2: Basic Orthographics

■ Lesson 4c- Production Theory 3: Advanced Orthographics and Pictorals

■ Lesson 4d- Production Theory 4: Cylinder Representation

■ Lesson 5- Creating CAD Detail Drawings

■ Midterm Exam

Lesson 3- Engineering Geometry

Resources

■ L3- Instructor Resources
Hidden from students

■ L3- Student Resources

Insructional Content

Class 8/18

1) TEXTBOOK READING: Chapter 3.8-3.19 (manual check-off)

2) L3- Presentation: Engineering Geometry

3) DEMO- Geometric Relations Practice *3D

4) DEMO- 3D Modeling Sketching Tools Tutorial *3D

5) DEMO- Variable Angle Bracket *3D

6) CA03- Class Exercises

Course Assignments

☐ Quiz03- Engineering Geometry

☐ A03- Engineering Geometry *SK

☐ 3DMA03- 3D Modeling Intermediate 1 *3D

☐ A04- Hex Slot Bracket *3D

☐ AL2- Active Learning- Engineering Geometry

Figure 1. Course Learning Management System Layout Example

assignments, students had to successfully complete assignments in sequential order and submit them through an online learning management system. They were unable to attempt the next assignment until they submitted the current assignment they were working on. These assignments included textbook assignments where students had to complete hand-drawn technical sketches, assessments, active learning modules, as well as CAD solid modeling practice. The only difference in assignments between the online course delivery versus hybrid was the delivery system.

Supplemental material was freely available online to all students in both hybrid and fully online classes. Utilizing a constructivist approach, the active learning modules were comprised of 10 units that were in-line with the course curriculum (Hedden, Worthy, Akins, Slinger-Friedman, & Paul, 2017). Each unit has content, real-world examples, reflection questions, hands-on activities, and quizzes. Each student receives a grade for completing each module associated with the course unit. In addition, students can use the resource when completing other course assignments or reflecting on instructor lectures.

Not only did the course restructure alter course delivery of content and resources to students, but it also additionally provided instructors an outline of steps for each lesson, further resources to utilize, as well as detailed solutions to problems students may encounter. Additionally, instructors were then provided the capability to arrange the online portion of the course as they wished. This entailed the ability to incorporate completion tracking where students completed a required task within the

online learning management software in order to move onto the next assignment.

Expectations for the course have changed to a certain degree. As summarized in Figure 2. students were expected to have access to certain devices such as a Windows computer, digital scanner, and a printer. Before the fully online classes, these were recommended for students to have but, if needed, were available to students through on-campus services. The software requirements changed as well. In previous years, students had to have CAD solid modeling software (licensed through the university), a PDF reader, and an internet browser on their computer. Since moving to fully online, students had to additionally have access to web conferencing software and a Virtual Private Network (VPN) in order to use university-provided off-campus software. Figure 2. summarizes the changes made during the course restructure.

METHOD

Research on the experience of students and instructors utilized an illustrated case study approach. With such a sudden change occurring just past the halfway point of a semester, researchers realized they had a unique opportunity
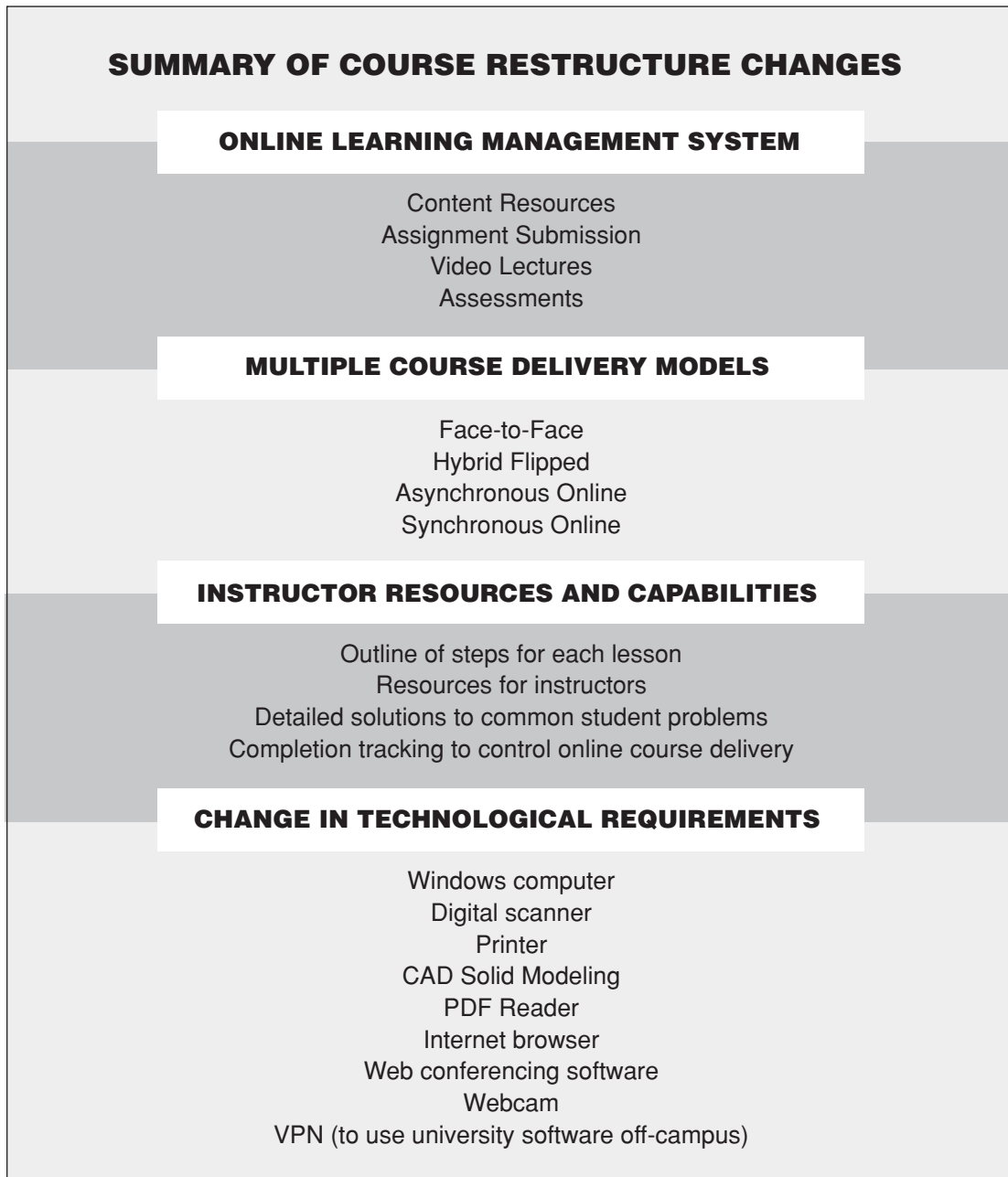
SUMMARY OF COURSE RESTRUCTURE CHANGES

ONLINE LEARNING MANAGEMENT SYSTEM

Content Resources
Assignment Submission
Video Lectures
Assessments

MULTIPLE COURSE DELIVERY MODELS

Face-to-Face
Hybrid Flipped
Asynchronous Online
Synchronous Online

INSTRUCTOR RESOURCES AND CAPABILITIES

Outline of steps for each lesson
Resources for instructors
Detailed solutions to common student problems
Completion tracking to control online course delivery

CHANGE IN TECHNOLOGICAL REQUIREMENTS

Windows computer
Digital scanner
Printer
CAD Solid Modeling
PDF Reader
Internet browser
Web conferencing software
Webcam
VPN (to use university software off-campus)

Figure 2. Summary of Course Restructure Changes

to observe a new situation and then report on the experiences. Once the Spring 2020 semester was completed, the opportunity to revamp the course from previous experiences was available and so it was done at a time when needed more than ever before. When the Fall 2020 semester rolled around, researchers not only had their previous experiences but now had a semester where applied changes could be observed and provide qualitative information from the instructors' perspective. To gather instructor data, interviews were conducted with four instructors of the introductory engineering graphics course. Each instructor met during a one-on-one semi-structured web conference where they were provided with five questions based around the research questions. Interview questions guided discussion in order to gain information regarding instructors' experiences as well as perceptions of the abrupt switch in course delivery and restructuring. Instructors were provided the questions before the interview so they could organize their thoughts. The questions guiding the interview were:

1. How prepared were you and students to switch to a fully online course delivery method?

2. How did your expectations of students change throughout the transition and into fall?

3. In what ways did your methodology or assessment methods change with the transition?

4. Did you notice any differences in the fully online course between Spring and Fall 2020?

5. Did course grading change at all with the transition in Spring 2020 or Fall 2020?

Each interview lasted between 45 to 60 minutes and was recorded as well as transcribed from which commonalities and unique experiences could be highlighted. Each instructor was notified that their identity would remain anonymous and permission to record the interview was provided.

Student qualitative data was collected from the Spring 2020 course evaluation surveys. The surveys provided information related to student experiences during the semester that started as a hybrid course and ended as an asynchronous online course. Identifying information from the survey was removed so that both the students and instructors were kept anonymous. Instructors also provided the research team with permission to use these written comments so long as personally identifiable information was removed. The research team was unable to attain student consent since the comments were provided anonymously by students.

RESULTS
Student Survey Responses

At the end of the course, students were asked to comment on the strengths and weaknesses of the course and instructor before and after the modality change due to COVID-19 and what could be improved upon in the course after the course transitioned to totally online. A total of 86 student responses were analyzed for this study with approximately 300 students being eligible to participate, representing a 28.6% response rate. Data cannot be triangulated because quantitative student evaluations were not available during this semester.

The first analysis of the student responses focused on how the students stated they felt about changes to the course delivery method. This was done by rating the student responses that specifically addressed whether they felt the course was better or worse, based on the responses. Most, 52.3%, of the students did not articulate whether they felt there was a difference or specifically stated that they did not provide a response that indicated a perceptible difference between the two delivery modalities. These responses were coded as "neutral." For some of these students, the modality change "did not alter" instruction or that the class "ran as normal" after the change. For some neutral responses, some students were either positive or negative regarding course delivery for both responses, prior to and after the modality change. Other responses were coded as neutral if the response was simply "good" or "bad" for both responses.

Thirty (35.9%) of the responding students were coded as "positive," meaning that the change to a fully online modality was perceived as a positive change from the original, hybrid, model of delivery. These students made express statements such as, "[the professor] did a great job" after the change or, "I do not think I could have asked for a better response." Other responses were not as clear in indicating a positive opinion of online learning but were clear in that they perceived the transition as positive. Statements like, "Professor [redacted] was very accommodating" after the change in modality were juxtaposed against their response to instruction prior to the COVID-19 changes such as "Professor [redacted]... was helpful in class." These differences in tone and superlative use were used in the decision to code their stated experiences as positive.

An identical process was used to code the student experiences as negative with 11, or 12.8%, of participants exposing negative

differences between the pre- and post-COVID-19 instructional formats. As with responses coded positively, some coded as negative were clear with statements such as, "After spring break, we had minimal instruction," and "... instruction completely fell through." As with positively coded responses, some negatively coded responses were more nuanced with differences in the responses before and after the COVID-related changes, including statements such as, "[Professor X.] is very nice and wants students to succeed" contrasted with statements that the change was "less than ideal."

Regardless of how the students felt about the modality changes, several themes were clear in shaping their opinions. Instructor communication, the methods and accessibility of that communication, flexibility in communication and assignment criteria and deadlines, pacing, and prior experience played a role in the students' opinions of how the instruction was delivered in the two modalities.

A large number of the students who responded to the course evaluation specifically mentioned instructor communication as either a positive or negative component when evaluating the course. Students found that extra class or office hour sessions, using web conferencing software, or allowing students to contact the instructor outside of these hours were positive. When instructors "did a good job updating [students] on what needed to be done as the course was transitioned online" and when the instructor "made [themselves] even more available" after the modality changed corresponded to positive opinions of the course. Similarly, students who felt there was "very little communication" after the transition or stated the instructor "was late to respond to most comments or questions" viewed the transition as negative. The importance of communication was most evident in the cases where the positive or negative view of communication differed from the overall response. For example, one student stated that after the transition, the course "was a little more difficult to follow," but "did appreciate [the instructor's] office hours and the adjustments made" to the course. Many students specifically mentioned the web conferencing software in a positive light regardless of the tone of the rest of their opinion.

Students appeared to like the option to work at their own pace and use the scheduled lecture and office hour times as personalized instructional time where they could get specific questions answered and clear up misconceptions or technical issues that arose during their independent work outside of class. This spoke largely to the students' preference for online, asynchronous, video lessons with the ability to "slow down the video and rewatch a section" while using the software. The presence of instructional videos after the transition was the most common theme throughout the student comments. One student's remark, "Make sure to have videos on all topics regarding [CAD software]" sums up the comments pretty concisely. The addition of these videos was frequently the reason many students were positive about the transition with students calling the changes a "much better format [that] allows more flexibility to us as students to work at our own pace, and allows us to jump in and ask questions we have rather than listen to questions we do not have any problem with."

Although only a few students specifically mentioned their prior experience with CAD software generally, those who did were all positive in their statements after the transition. Given the number of references to technical questions and issues related to the software as it related to office hours and individual instruction, this prior experience seemed to positively affect their post-COVID instructional experience.

Instructor Interviews

Instructors provided valuable input regarding their experiences with the sudden changes in teaching environments. Prior to the pandemic, the introductory engineering graphics course was presented through a hybrid environment where students would meet in person for a lecture and then conduct assignments through an online learning management system during the remaining part of the week. While resources and quizzes were available online, sketching assignments and exams had to be submitted by hand and face-to-face time was used for the lectures, guided practice, exams, and open lab time. During this time there was discussion of what it would take to design a completely online engineering graphics course, but action to restructure was not initiated until the dire situation of all courses being transitioned online in the spring of 2020. As stated by an instructor, there was a discussion of transitioning to a completely online environment, but the use of web conferencing software was not included in the discussion. With the onset and spread of the pandemic, instructors paid attention to the news and the courses of action taken by educational institutions around the world. It was known that change was approaching, however, the dramatic impact of the transition was still

unexpected and for which unprepared. As one instructor stated, "there was no doomsday scenario in place" for such an event.

Course instructors were experienced with technology, so one thing they were prepared for was the increased use of technology such as online learning management systems and digital resources. An instructor discussed how while they were prepared physically for a transition, they were unprepared mentally. The transition occurred later in the semester so there were only four lessons remaining before the final exam. The instructors worked as a team, and each took on one of the four lessons converting them to a fully online model. Students in each course then experienced, in an asynchronous model, each of the four lessons from the team of instructors while finishing the course. Students had the opportunity during the week, when needed, to meet with instructors through university-provided web conferencing software. Major challenges that accompanied the sudden transition to a fully online environment included experiencing instruction through a delivery model unintended from how the course was initiated and the need for instructors to be more empathetic to the dramatic changes experienced by their students.

Multiple instructors discussed how some students experienced the pressure of having to focus on family needs rather than coursework, while other students possibly returned to less-than-ideal living conditions. It was highlighted in one interview how hundreds of students in this course went from being in one centralized area of the southeast United States to being spread out over the world. When the university campus closed, students were forced from their on-campus living quarters to back home or wherever they could find quarantine space. Some students had to leave the country and go overseas. This dramatically impacted instructors' time because they could no longer hold regular office hours during the typical workday and they had to accommodate students' needs to meet virtually through web conferencing at any time of day. The dramatic transition from face-to-face to online brought upon instructors an unexpected increased involvement in the remaining semester as identified in all interviews. These changes ultimately lead to a restructuring of not only the engineering graphics course but also the methodology of instructors.

Over the summer of 2020, the challenges and lessons learned were reflected upon by instructors while the restructuring of the introductory engineering graphics course occurred. The course was redesigned so that it could be delivered in multiple formats through face-to-face, hybrid flipped, or online (asynchronous or synchronous) models. The fall 2020 semester began with courses being delivered through a hybrid flipped model where students would gain content knowledge online and then meet in person to conduct activities and ask questions. However, both instructors and students understood there was an increased chance that courses would be immediately switched online shortly after the beginning of the semester. Instructors discussed this with their students and reassured them that steps had been taken to establish a structure that would support such a transition. Such a transition did occur and this time instructors were highly prepared and possessed increased confidence in holding their classes fully online. One instructor discussed during the interview how they communicated with their students on the possible pathways the semester could go given the experience from the spring. When the course went fully online, the instructor then surveyed students for whether they preferred an asynchronous or synchronous course delivery, and students voted for synchronous course delivery. With these results, the instructor had students meet once a week through web conferencing software where they were able to discuss course content and provide step-by-step guides on how to use CAD solid modeling software.

Accompanying the restructure of the introductory engineering graphics course was greater flexibility in how students attended class. Instructors were able to hold either synchronous or asynchronous course delivery where attendance could be taken either through students attending online classes during the week or watching the recorded lectures through the online learning management system. Students had to either attend lectures or watch the recordings in order to know what assignments were due next. As a result, either of these actions counted towards course attendance. All interviewed instructors used the weekly synchronous sections as a time to guide students in the content application, a time as tech support, or a time for students to come in and ask questions regarding the recorded lectures or assignments. Attendance to these sections was optional for students as they had access to all content online.

Instructors identified that a challenge with the situation is that they had to proceed through the semester at a slower pace when demonstrating

CAD software because students had to switch between computer windows. To resolve this, it is recommended that students have a dual monitor setup, although it is understood that may be difficult for students on a strict budget. An additional change in methodology includes engaging students and informal assessments. All instructors highlighted challenges associated with engaging and informally assessing students due to not being able to walk around a classroom and ask questions to gauge understanding, make observations, or to have students raise their hands or give a thumbs up to confirm understanding. While web conferencing software offers the ability to raise a digital hand or thumbs up, it is not as simple as the ability to walk around in person and observe students' work-in-progress to make corrections. This occurred when teaching technical sketching as well as software practice. Instructors were unable to walk around to gauge student ability and understanding of techniques as students were completing the drawings and models.

Formal assessment types remained the same aside from the delivery method of a few of the assessments. An identified change that instructors experienced was that grading took a long time due to a shift in the submission process and grading tools. Any physical worksheets which students had to complete and submit through their course textbook had to be scanned and uploaded through the learning management system as a PDF whereas previously they could be removed from the textbook and submitted by hand in class. With everything submitted online, instructors had to take the PDF and, while using editing software, provide feedback versus taking a pen and grading by hand. There are tools available such as styluses and PDF editors which instructors took advantage of to alleviate digital grading challenges.

With the stresses of the course transition in the spring and the implementation of the course restructure in the fall, all instructors did not change the level at which they graded student work. From the interviews, what did change was leniency on accepting late assignments from students given that everyone was experiencing an unexpected, stressful change. Instructor expectations of students had to change, according to one of the interviews, given that students are experiencing a new education environment where new challenges are being presented. In addition to the challenge of students having to relocate there was also the challenge of students having to share a lot of their equipment with family members. For an online course to function effectively students need a reliable internet connection (Srichanyachon, 2014). During the pandemic, students likely had to remain at home where they may not have reliable internet or where their available internet bandwidth had to be shared with family members working from home or also attending online courses. This resulted in instructors having to be more understanding of the limitations placed upon students. Students were still expected to submit high-quality work, according to interviews, but there was more leniency as to when that work was submitted. Instructors placed more tolerances on due dates without penalty or need of student explanation.

Changes in course delivery and instructor experiences, identified in Figure 3 on page 20. also included changes in the required technology. While the course was applied as a hybrid course, assignments were still submitted by hand and face-to-face instruction was provided. However, with the transition and restructuring, instructor reliance on technology for instruction increased. All interviewed instructors discussed how document cameras were in higher demand so they could scan work and demonstrate technical sketching online. Each instructor also highlighted the need for web conferencing software in conjunction with a reliable internet connection to successfully communicate with students. When providing feedback on coursework, all instructors discussed how they now had to provide grades and feedback digitally to students versus handwritten grades and verbal feedback when meeting face-to-face. In order to provide digital grades, some of the instructors used a PDF editor in conjunction with a stylus to write on submitted PDF versions of assignments. In addition, instructors also used comment sections of the online learning management software to provide feedback on students' work.

DISCUSSION

Accompanying the worldwide emergency response was the need for changes in delivery methods of technology, engineering, and design courses. A foundation for such a dramatic shift in course delivery had already been established since the course was originally a hybrid course due to the need to meet the needs of large course sections of 60 or more students. Online content in addition to supplemental materials was already in place so the only thing needed was the addition of video lectures and restructuring of online evaluations. When instructors had to meet with students through class or office
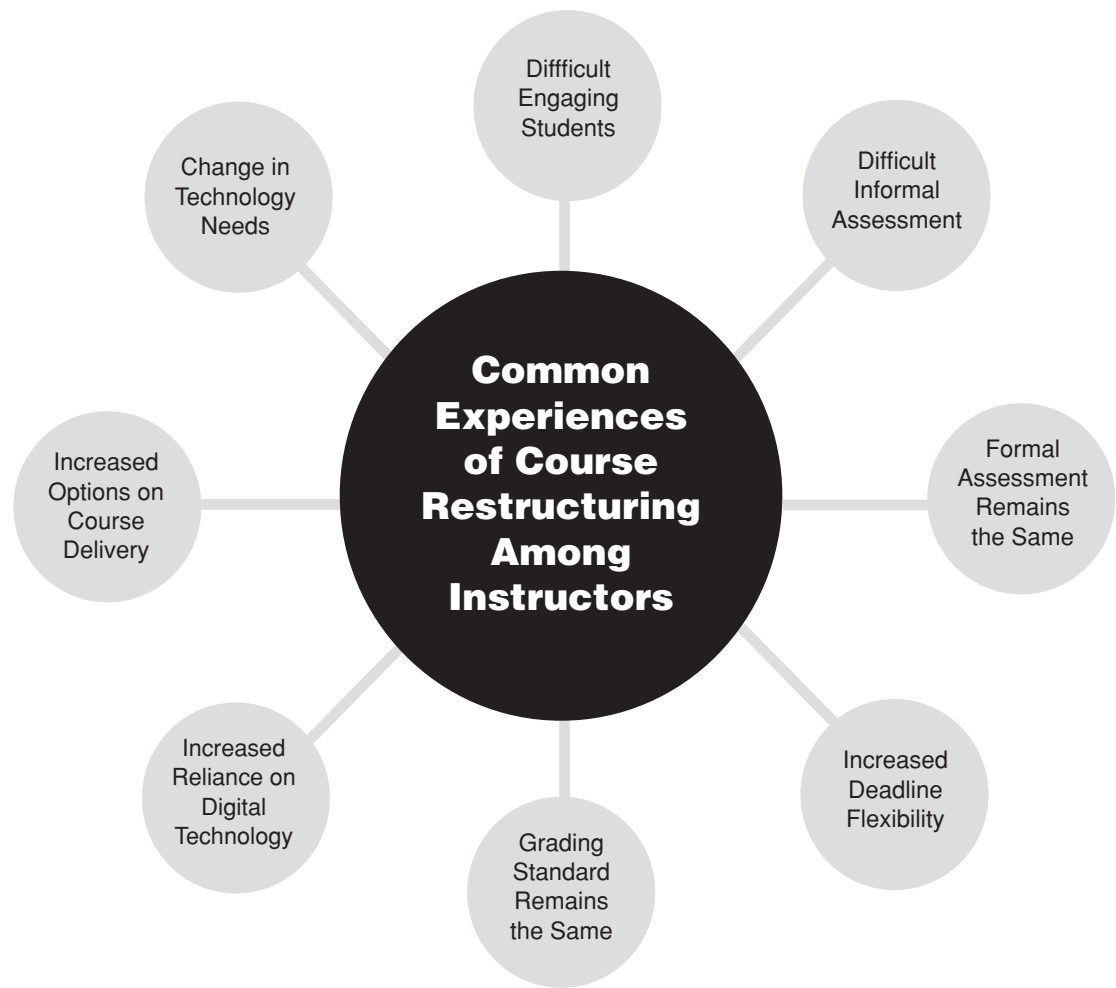
Figure 3. Common Experiences of Course Restructure Among Instructors

hours, web conferencing software was used instead of meeting face-to-face. This allowed for social distancing to occur while still delivering valued instruction. Due to the remote nature of class, which online course delivery brings, additional technology was required which altered equipment expectations of the course. If a student did not have the equipment, they could no longer go onto campus to access the required equipment and had to find another method of procuring required equipment.

While teaching the course fully online was new territory for the instructors, they were able to accommodate student needs by utilizing an existing online learning management system in conjunction with their online lessons. As a result, students were able to complete assignments regardless of their location. As evident from positive responses, students were appreciative of switching to a fully online course delivery given the emergency situation. The pandemic was a stressful situation for many people to some degree. There were changing living locations,

new family situations, lack of socialization, and a fear of contracting the virus on top of the already existing academic stresses (Benjet, 2020). Students had to deal with these issues while trying to remain focused on their studies. Student stress can lead to a negative impact on their academic performance, motivation, as well as engagement (Pascoe et al., 2020).

Engagement from students occurred in the form of their utilizing online content as well as their participation in the synchronous online course time. Online content, such as the video lessons, was well received and appreciated by students as it afforded them the flexibility to watch lectures when they had the opportunity and to rewatch portions when needed. Additionally, online content afforded the appreciated opportunity of moving at a pace preferred by the student. With this ability, students were able to use instructor course time as a time to gain further guided practice or ask the instructor questions versus listening to traditional lecture delivery.

A beneficial trait that was identified by both instructors and students was flexibility. Instructors practiced increased flexibility of due dates, increased empathy for students, as well as their ability to adjust course delivery. Instructors discussed an understanding that the pandemic brought upon unprecedented stresses and that, as a result of such a situation, an increased amount of empathy was needed. This empathy brought about an increase in flexibility of communication, assignment criteria, and due dates. Students responded in their course evaluations how the trait of flexibility was appreciated. When flexibility from students was identified, it was not just flexibility in the due dates that was appreciated but the flexibility in communication and content delivery. Students valued being able to watch video lectures online and then being able to meet through web conferencing software during scheduled course time to ask questions. In addition, flexibility occurred by allowing students to attend regularly scheduled course time when it met their schedule and when they had something to discuss.

Flexibility through communication occurred by instructors opening up more of their schedule to accommodate student needs. As discussed by instructors, students were in varying time zones and on varying schedules so there was a need to be more flexible with schedules. Students responded positively to instructors hosting online office hours, using web conferencing software to meet, and scheduling time outside of office hours as needed. Communication through the online learning management system was also appreciated. Online course delivery enabled increased instructor use of the online learning management system to communicate details of expectations. Student survey responses identified maintaining and communicating expectations as a benefit to their completion of assignments.

As flexibility was incorporated and effective communication was maintained, students were still part of a high-ranking university, instructors still upheld the same standards of high-quality work expected to be submitted and graded accordingly. All instructors highlighted how even though they enveloped increased flexibility, they still graded to the same degree as before the onset of the pandemic. While the grading standard remained constant, what did change was the method of assignment submission and method of grading. During the hybrid class, some assignments were turned in online while other assignments were completed and turned in by hand. With fully online course delivery, students still completed some assignments by hand but were required to scan the document and then submit a digital version of the assignment. With the course restructure, instructors relied heavily on technology to both deliver instructions as well as to provide feedback.

CONCLUSION AND RECOMMENDATIONS

COVID-19 brought about unparalleled challenges to multiple facets of life and society. Among many fields, one of the areas dramatically impacted was education. Technology, engineering, and design education courses around the country had to abruptly change long-term course delivery methods. As pressured by the pandemic, a hybrid flipped model Introductory Engineering Graphics course used its foundation along with experiences from the emergency transition of Spring 2020 to restructure the course. This process is only the experience of one institution and may not apply to other schools. Attention should be paid to the matter that the course had established preparedness for the transition to fully virtual education that was significantly assisted by the readiness of the active learning module integrations as well as the existing asynchronous conceptual instruction sessions that were previously prepared. In addition to the preparedness, flexibility and willingness to adapt on the part of the instructors led to an increased ability to migrate course instruction and activities into a distance modality.

Pandemic induced change to fully online course delivery provided knowledge and experiences from which future institutions can apply to course delivery. The reformatted introductory engineering graphics course serves as a model of multiple course delivery options as well as how to serve large populations of students for technology, engineering, and design education courses.

It is recommended that in order to meet the needs of a pandemic-impacted population that multiple course delivery models be prepared for whatever situations arise. This can be achieved through organized, clear, and phased learning management system materials. Furthermore, providing intact assessment processes and means that align enhanced course expectation clarity may provide positive experiences for students and instructors.

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