UNDERGRADUATE STUDENT ENGAGEMENT WITH SYNCHRONOUS AND ASYNCHRONOUS COURSE ELEMENTS

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Abstract – *This study aims to understand student engagement with synchronous and asynchronous elements across the lecture and laboratory sections of a Civil Engineering undergraduate course. This course provided a unique chance to observe and compare synchronous and asynchronous elements as they run concurrently and in parallel. Behavioural engagement, a measure of how many students accessed a course element, was determined from logging data obtained from the course website. The experience of students taking part in virtual laboratory experiments was evaluated with surveys to monitor perception of the experiential laboratories transition to a virtual format. Examining the logging data of 95 students, it was found that students engaged with synchronous lecture material at higher rates and more consistently throughout the semester, averaging 69% participation, whereas asynchronous lectures averaged 33% participation by the suggested date of viewing. Notably 60% of students accessed the supplementary asynchronous concrete lab video within the recommended timeframe, suggesting when provided as a supplementary resource and in a creative format, there may be higher levels of engagement. This study shows that asynchronous content, despite being valuable for self-paced learning and accessibility, should not be the primary form of student engagement as students accessed it at a less consistent and routine pace.*

Keywords: Online education, asynchronous learning, synchronous learning, student engagement

1. INTRODUCTION

The COVID-19 pandemic caused undergraduate courses across Canada to suddenly transition to a predominately virtual format in the Winter 2020 term. Such an unforeseen and significant change to a virtual learning environment was a challenge to undergraduate engineering students, who to this point had been accustomed to predominately in-person instructions. The challenges of students in the Winter 2020 term during COVID-19 was evident with many institutions providing students with alternative grading options to compensate for the stressful situation, including dropping Winter 2020 classes with no penalty at any time or having their grades presented simply as a Pass or Fail outcome.

To quantify the challenges during the Winter 2020 semester identified by students and educators, Wiley Education Services circulated a survey across seven American public and private institutions (reports can be accessed by contacting the participating institutions) [1]. Key findings of the report include that 73% of students felt that they did not learn as well as they would have, had the semester remained in person [1]. Students indicated that direct, one-on-one contact was the most effect method of learning remotely, and within a group setting, live (synchronous) lectures were most effective, followed by pre-recorded lectures.

While many courses tend to favour one form of instruction (synchronous or asynchronous), from the aforementioned survey and other studies, it is suggested that providing elements of both formats better accommodates for varied student learning styles [2]. When provided with the autonomy to choose between these two formats, students tend to choose the synchronous option despite no consistent statistical significance in grades between formats [3]. What is not well understood is student behavioural engagement, most often described as use of a specific resource [4], with different synchronous and asynchronous elements within a single course. The impact of student engagement with synchronous and asynchronous materials on student learning is also an area which lacks investigation within the Wiley survey as the statistics mention the two learning formats and gauge student perception of each, but do not quantify the actual rate of engagement had with different course elements.

The purpose of this research is to address knowledge gaps in quantifying the impact of student behavioural engagement with synchronous and asynchronous course elements on student achievement. Further, this research aims to assess how student perceptions of their learning were impacted by use of the different course elements, that included activities designed to foster student engagement

within a virtual format. This study will generate data specific to Canadian engineering institutions that can inform the design of future in person and virtual iterations of similar courses.

2. METHODOLOGY

Herein, a case study is considered, consisting of a second year Civil Engineering course offered in Fall 2020. Offerings of the course prior to COVID-19 consisted of three hours of weekly in person lectures supplemented with one hour of weekly tutorial time and a two-hour experiential lab section every week. The transition to online learning required that all elements become virtual for Fall 2020. The instructor of the course is also affiliated with one of the American institutions that participated in the aforementioned Wiley survey [1], and as such was provided with the results of the survey specific to their associated institution (a predominantly engineering and related degree institution). Results of the survey helped to inform aspects of the virtual course design, including that students specified that synchronous lectures over platforms such as Zoom were the most effective method of learning remotely (n=4280) [1]. The synchronous lectures were valued due to instructor presence and interaction, while asynchronous lecture provided students with more flexibility in their schedule. The synchronous lectures were also significant as they provided structure to the undergraduate experience. From these and other data, the course instructor aimed to deliver a course that aligned with the successes observed in the Winter 2020 semester, based on a pedagogy that even small changes in curriculum can have a large impact [5] and as such should rely on research where possible.

2.1. Asynchronous and Synchronous Elements

Prior to the start of the course, the authors conducted a brief survey of the student body at the Canadian institution where the course was held, with the purpose of understanding the needs of the specific student body, including logistical challenges such as if accommodations would be needed for students in different time zones.

For the Fall 2020 version of the course, the course was formatted with three hours of weekly lectures divided into an asynchronous pre-recorded and a synchronous component. As the course herein uniquely consists of synchronous and asynchronous course elements, the strengths and weaknesses of these course elements can be studied comparatively.

The asynchronous lecture content consisted of two hours of lecture material made available to students weeks in advanced on the course website and titled such that students knew what the latest day it was suggested they watch based on the pacing of in-person instruction (Ex. Module 1: Introduction Part 1 September 9 2020). The two hours of asynchronous lecture were split into smaller videos averaging from 30-45 minutes each to encourage students to take breaks as needed. The need for breaks was a concern noted by students in the pre-term survey of the student body. Ideally videos would be 20 minutes long as this was the ideal time found by Long et al. [6] for optimal student engagement with flipped classroom videos. Using an asynchronous format would also assist students that experience intermittent connectivity issues that would hinder their ability to follow along with live videos.

Synchronous content consisted of an hour-long live lecture held over Zoom which served to go through the asynchronous material in greater detail. Each live lecture also tried to include a guest speaker, culminating in a Q&A period. Throughout the lecture the tone was kept casual and humorous making the lecture feel more like a podcast, with work by Edirisingha and Fothergill [7] demonstrating that students enjoy the humorous and more casual atmosphere created by a podcast style of presenting. A key concern when planning the synchronous lectures was that students would be located in different time zones due to the international and out of province student population. Based on the pre-term survey before the course started, nearly all students had no issues with large differences in local times, and as such no rescheduling to avoid synchronous lectures taking place at inconvenient times (late night/early morning) was required.

In previous years, the lab component for the second year Civil Engineering course was very hands on, providing students with the experience of testing different materials covered in class to better understand their mechanical properties and behaviour. Laboratory sections during Fall 2020 were moved online through two-hour weekly sections hosted on Zoom, for a total of eight weeks. These eight weeks were split into two four-week blocks which covered steel material testing (Lab 1) and concrete testing (Lab 2) respectively. Each lab had a report submission due one week after the last session for that block, but the medium of the report differed for each lab to provide more opportunities to those who have different learning styles. Lab 1 required a group video report and Lab 2 required an individual written report. The first block contained traditional forms of videos to walk students through testing, predominately recordings of a test occurring with key points appearing as the video progressed.

In order to see student reception to a more interactive and approachable medium, an asynchronous video titled “Cooking with Concrete” was created. This video was planned to deviate from a simple static recording of tests in a few notable ways. Firstly, the video was produced in the summer of 2020 by two undergraduate students who had previously taken the course. This decision was based on success seen by Jordan et al. [8] when they provided student

in an Organic Chemistry lab with supplementary videos generated by undergraduate students. One student was filmed carrying out all the steps required in casting concrete, from mix design and mixing to casting and demolding, while the other student narrated the video in an informative yet lighthearted and at times comical style, with visuals and audio being reminiscent of a cooking show. The film was gender balanced. The end of the video culminated with a student making a nutty chocolate bar recipe as an analogy for mixing concrete with ingredients such as chocolate powder, nuts, sugar, salt, and milk replacing the cement, coarse and fine aggregates, and water student would mix for a batch of concrete. The student also demonstrated a failed mixture by adding "too much" of one ingredient. Baking was decided as a lighthearted medium since the Wiley survey highlighted a concern for mental health [1]. Such a medium may promote students to participate in creative acts such as baking which has been suggested as a form of stress relief during the lockdown [9].

2.2. Measuring Student Engagement

The logging systems within Moodle and Zoom were utilized to monitor behavioural engagement with asynchronous and synchronous elements of the course respectively. For a student to have been considered to have engaged with an asynchronous lecture by the suggested date they had to have accessed it two hours or more before the start of the corresponding synchronous lecture. Tracking engagement of students with the Cooking with Concrete video was based on a student accessing the video a week prior to the submission of the lab report for the corresponding lab sections. To further understand self-directed learning with asynchronous lectures, the videos for the week of October 9th were examined for student engagement throughout the term; specific interest paid to engagement after the suggested date to watch. Observations on self-directed learning were determined based on the number of students accessing it in a given week and the amount accessing it for the first time in a given week. The week of October 9th was chosen as it contained material that was examined on a mid-term following reading week as well as on the final exam. Additionally, it is assumed that students had started becoming accustomed to the course and as such would be exhibiting tendencies to participate in proactive self-directed learning.

2.3. Evaluating Student Perceptions

The course studied is notable for being one of the most experiential courses of the Civil Engineering program. Part of this is due to the students having to actively participate in all stages involved in the design and testing of a concrete mix. To quantify how students perceived the move to the virtual format, four surveys were circulated via Moodle in order to understand student expectations of the laboratory section heading into the course, their views on the individuals labs, and their views on the laboratory section of the curriculum as a whole after completing the course. The surveys were distributed at different times during the term (see below). Procedures for ethics were followed which included though not limited to, standard rights to withdraw, and notification of data collection. All surveys primarily consisted of multiple-choice questions that asked students to rate agreement with a question using a 5-point Likert scale. A quality assurance question was included which asked students to choose two specific options. The two options changed with each survey, so any responses where a student was simply clicking random answers could be identified and removed from the analysis.

The two surveys dedicated to quantifying student expectations (prelab) and their experience (post-lab) were based on the Meaningful Learning in the Laboratory Instrument (MLLI), developed by Galloway & Bretz [10], but were shortened from the original 31 question to 11 including one question asking about their perception of losing out due to lack of hands-on lab experience. Although the MLLI has been applied to understand student perception of in person labs after being provided supplementary video coving pre-lab material, experimental procedure, and data analysis [11], it would still provide useful in understanding the perception of transitioning to a virtual format. Two additional surveys, one for each lab, consisted of 7 multiple choice questions which aim to quantify the quality of instruction, ease of understanding, self-efficacy, and perceived competence. All surveys were answered as fully anonymous in order to provide students with the sense they could be as truthful and critical as they desired. Students were notified that if participation rate across all four surveys was 80% or above then they would be provided with one exam question exactly as it would appear on the final exam ahead of time. It was hoped that this would provide additional motivation to combat survey fatigue. A question was provided to the students.

The post lab survey based on MLII was also modified to include four additional multiple-choice questions which asked students to choose which lab was more useful, which lab had the more effective delivery method, if they preferred the written or video report submission, and if they would like more opportunities in the future to submit reports in a video format. An optional open-ended question asking students to explain why they preferred the option chosen was also included for each question except for the last. The full surveys can be found in Appendix A.

2.4. Limitations

Limitations with this method of measuring student behavioural engagement should be addressed. The use of Moodle's logging system can only state the instance a student accesses a resource but has no ability to provide the

duration a student interacts with the resource itself. This means there is no way to determine the quality or length of engagement that a student is having with a video. Using alternative platforms (ex. Echo360) could remediate this as it can track the amount of time a student spends watching a video but again the question arises that there is limitation to differentiate a student who actively watches and engages with the entire video and a student who opens the video and walks away. In the course presented for this study, Echo360 was not used due to technical issues. Zoom logging also poses a similar limitation revolving around the ability to mute and disable one's video. It is unethical (in the authors shared opinion) to require students to have video and audio turned on at all times.

3. RESULTS AND DISCUSSION

3.1. Student Engagement with Asynchronous and Synchronous Elements

There were 12 weeks' worth of asynchronous lectures and 11 weeks of synchronous lectures, the discrepancy being due to no live lecture the week of the midterm to allow students a reprieve. Synchronous lectures had a mean student engagement of 69% (σ=11.8%) while asynchronous lectures only had a mean engagement rate of 33% (σ=22.8%) by the expected date of viewing. This demonstrates that students engaged at high levels and more consistently with synchronous lecture elements in this course than they did with similar asynchronous elements by the suggested timeline. Additionally, examining the engagement rate of students with the asynchronous element of the laboratories, "Cooking with Concrete", there is an engagement rate of 60% by the suggested date. This suggests that in general asynchronous elements when used as lectures have a significantly reduced level of engagement, but when provided as supplementary resources in an engaging and creative way, can have engagement similar to synchronous content.

With the workload that students experience over the term changing due to the scheduling of assignments and examinations overlapping during certain periods the engagement rate for each week's asynchronous and synchronous material was compared, shown in Fig. 1. The observations made on the engagement over time serve as a hypothesis and would require further investigation into the state of stress and fatigue students feel throughout the term based on periodic surveys.

Initially high levels of engagement are observed in both types of lecture which likely corresponds to students wanting to attend introduction classes as well the students having the lightest workload since assignments, tutorials or labs have not begun. After the second week asynchronous rate of engagement by the suggested timeline starts declining significantly in comparison to synchronous content. This can likely be attributed to students experiencing increased workload due to commencement of labs, tutorials, and assignments which they prioritize over watching asynchronous content. Before reading week, the final live lecture before the midterm happens and sees the largest attendance of any live lecture with asynchronous material achieving the lowest levels of attendance up to that point. Students were likely expecting synchronous lecture to have some element of review as well as possible tips for the coming midterm while asynchronous content had been prepared well in advance and as such would likely be viewed as lower priority.

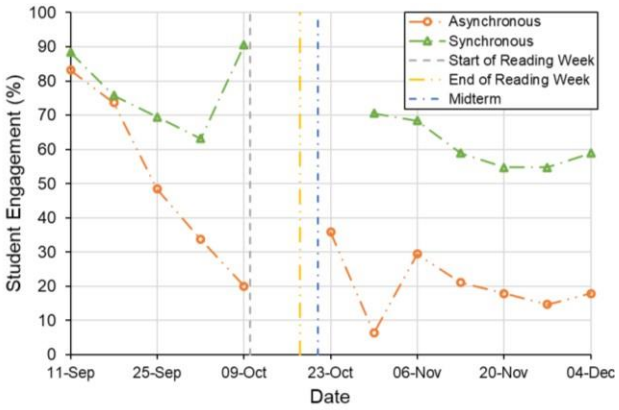

Figure 1: Student engagement with synchronous and asynchronous lectures by the suggested time.

Following the reading week and midterm, a lowered rate of engagement across both types of lecture was observed and hypothesized by the authors as due to fatigue throughout the term. Following the week of November 6th, the difference in engagement rate between the two styles appears constant averaging 39%, with a standard deviation of 1.5%. This suggests students finally settled into their learning style, understanding if they are the type to proactively stay up to date on asynchronous and synchronous lectures. The student engagement for asynchronous content on the week of October 30th was 6%, the lowest of the term. The cause for this low engagement can be attributed, as the authors hypothesize, to the six assessments across four courses (two midterms including the course studied, two major assignments, and two quizzes) that occurred in the 10 days prior for a second year student enrolled in all of the recommended courses (noted from student feedback).

Based on such a reduced engagement with material, it is evident that for asynchronous content to be engaged with on a suggested and routine timeline, attention must be paid to ensure students are not overwhelmed with a large overlap of assessments in the forms of midterms and assignments. This will require that scheduling of assessments not simply

be a course level concern but managed at a faculty level with continuous discussion between instructors of courses for a given year of study. Should this not be the case, asynchronous components will understandably be sacrificed to a later day in order to lighten the mental load, and stress, experienced by students during these overwhelming periods.

To further understand how student engagement with a resource may vary over time, the asynchronous lecture for the week of October 9th was analysed, as shown in Fig. 2. The asynchronous lecture was released four weeks in advance, on September 10th, however it was only utilized by students starting the third week it was available (a week prior to when it was expected they should watch the material by) with 3% of the class accessing it by that point. Only 20% of students engaged with the material by the suggested date which doubled to 40% of students the following week; likely corresponding to students trying to catch up on material over reading week. The week containing the midterm where this material was tested saw 48% of students engage with the material, with 29% accessing it for the first time during the course. Both these measures of engagement are the largest of any week for this resource during the entire course and suggest that a significant portion are cramming for the midterm having never seen the material before. The week prior to the exam 28% of students use the resource, most likely for review.

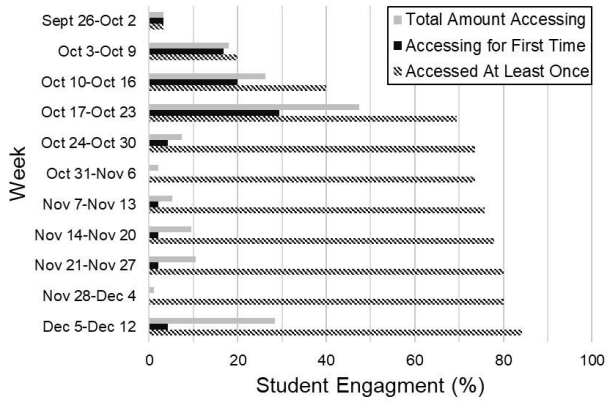

Figure 2: Student engagement with "Module 9: Types and Properties of Concrete Part 1 - October 7th, 2020".

These observations suggest that although useful for accessibility, asynchronous elements are not often used by students to proactively practice self-guided learning but are instead pushed back to allow for more time to focus on assignments and other examinations which are more pressing. This is not necessarily a shortcoming of students but simply a by-product of the intense time-management demands required to balance school, work, interpersonal relationships, and mental health. This also suggest a significant number of students end up "cramming" asynchronous lecture prior to a large assessment. Synchronous elements on the other hand help to provide some regiment and stability to student's time commitments and self-guided learning.

One of the questions in the survey completed following the concrete lab gave students a 5 point Likert scale (1-strongly disagree to 5-strongly agree) and asked them to respond to the question "[t]he lab video "Cooking with Concrete" would be valuable to future students as a pre-lab supplement." Students gave on average a 4.42 (σ=0.73 and n=31) which suggests that although these asynchronous resources will have lowered rates of engagement, students do value having them as supplementary aids. It should be noted that although only 60% of students engaged with the video prior to the end of labs, by end the time the survey was closed, December 11th, 97% of students had accessed the video. This discrepancy suggests students waited until they were finalizing their reports on the lab to make use of the lab video.

These findings suggest that for similar courses, it may be advantageous to have predominantly synchronous instruction that are then supplemented with asynchronous content. This could include pre-lab videos like Cooking with Concrete and snippets of previous years' lectures to give them idea what they will be learning in a given module. To continue to ensure increased accessibility, synchronous content could be recorded and provided to students who require an exemption, such as internet issues, appointments (medical, legal, personal, etc.) that cannot be missed, or simply those who cannot access campus due to inclement weather conditions. Additionally, once a lecture has been recorded the audio can be easily closed captioned which is quite valuable for those with accessibility needs due to hearing impairments. This would also assist student accommodation centres as they would no longer have to rely on finding student volunteers to annotate/take notes during lectures and make engineering courses more inclusive to those with conditions affecting their hearing.

3.2. Student Perception of Virtual Labs and Impact on Learning

The Pre-Lab MLLI survey received 75 responses, followed by 69 responses for the Lab 1 survey, 31 respondents for the Lab 2 survey, and 32 respondents for the Post-Lab MLLI survey. It is evident that student responses dwindled due to survey fatigue which was only heightened due to the increased amount of surveys regarding COVID-19. The surveys circuited after the completion of each of the two lab sections showed that students viewed the quality of instruction, their self efficacy, and self-competence for each lab in a neutral or agreeable light, ranging from a mean of 3.55 to 4.24 (Q15). Additionally, students showed little difference in perception between labs with questions one through five

only having a +/- 5% change between surveys. The students did have a very neutral stance on if they viewed the labs as suitable replacements for a physical lab with mean responses being 3.38 (σ=1.09) for Lab 1 (Steel Material Properties) and 3.06 (σ=1.01) for Lab 2 (Concrete Material Properties). This more negative view associated with Lab 2 (a 9.25% decrease compared to Lab 1) may be attributed to the fact that the process for testing steel is more static and simply involves preparing a bar specimen of known length and diameter by attaching an extensometer, and inserting it into a tension testing device and as such is easily captured in video. Lab 2 on the other hand is much more intensive and would have students weighing, mixing, casting, demolding, and testing their concrete mixes and would clearly be a more hands on activity that would allow students the chance to have a uniquely in person experience in stark contrast to their virtual learning environment.

The results of the MLLI surveys once again showed students were in general agreement with prompts depicting meaningful learning, as Questions 1-3 and 6-8 had mean scores ranging from 3.53 to 4.64. These surveys showed a trend that after experiencing the labs students had a less agreeable response to prompts with the above questions showing a difference ranging from –8.7% to 6.1%. This could be attributed to students being optimistic about the course, in addition to uncertainty about what a Civil Engineering lab would entail. There was a significant decrease of 17.7% in how confident students felt with using laboratory equipment once they finished the course. There was another significant decrease of 10.9% in how intrigued students were with lab equipment. The most striking example of how the virtual environment impacts student perception of is their view on losing out due to lack of hands-on experience which students took a mean neutral stance prior to start to labs but after labs were completed had come to agree with the sentiment, an increase of 31.4%.

These findings suggest that students are trying to make the best of their education and the situation they find themselves in but understandably, they feel that transitioning of hands-on laboratories to a virtual format is causing them to lose out on experiential learning. In order to combat this, designing accessible activities that try and capture that hands-on aspect of the laboratories could be beneficial as is being investigated elsewhere by the authors.

Added to the post MLLI survey were two questions asking which lab students found 1- more useful and 2- more effective, with 69% and 59% (n=32) of respondents choosing Lab 2 for each question respectively. Based on an open ended follow up for why they found a particular lab more useful, the most common reason for students who favoured Lab 1 (n=10) was that they found it useful to work in a group (70%) and that Lab 1 had a slower pace making it easier to understand (30%). Of the students who found Lab 2 more useful (n=22), the most common rationale was that they liked working individually as they needed to understand every component (18%), and that they found it more challenging (14%), more applicable to practice (14%) or more interactive (14%).

When further asked why one lab was more effective over the other, students who found Lab 1 more effective (n=13) indicated they found it more straightforward and therefore easier to understand (46%), and that they found the video submission (23%) or group work (23%) more effective for their learning. Overwhelmingly, students who found Lab 2 more effective (n=19) indicated that it was due to the "Cooking with Concrete" video (58%). A further 32% said they found the lab to be more effective due to the written lab report.

3.3. Student Perception of Video Report Submission

When asked if students preferred submitting a lab report in a written or video format, 66% (n=32) chose a video submission as their preferred choice. The predominate reason stated for preferring a video format was the ability it gave them to be creative and express themselves compared to the strict guidelines associated with report writing (38% of those who preferred video). Other reasons stated included students perceived it as the easier and less time-consuming format which is useful in virtual learning (24%) and that it was more effective for their learning (17%). In a learning environment where students spend hours at a time looking at Zoom screens and typing out reports, the ability to have a non-traditional and creative form of submission becomes more appealing. Such reasoning would also explain why 88% of students that responded stated they would "like to have more opportunities in future courses to submit reports in a video format", as even those that typically prefer a written format may enjoy the opportunity to try a creative outlet.

4. CONCLUSION AND FUTURE WORK

The purpose of this study was to understand the levels of student engagement with synchronous and asynchronous course elements, as well as factors that might contribute to a high or to a low engagement rate. Further, this study aimed to evaluate student perceptions of the synchronous and asynchronous course elements, generating Canadian-specific data that could be used to design future similar courses to be accommodating to student needs.

When provided with both asynchronous and synchronous elements within a single course it was evident that students' engagement by the suggested date with asynchronous content was significantly lower on average and showed less consistently across the term. One of the most detrimental situations that can hinder engagement

with asynchronous content is an overload of assignments and midterms. The authors recommend proper communication to occur in faculties such that instructors teaching the same cohort co-ordinate assessments in a balanced manner throughout the term. Further, it was found that a significant portion of students will often only access a given asynchronous resource for the first time prior to a major assessment, suggesting these asynchronous elements may be prone to promoting 'cramming'. As these observations on student stress are subjective and merely hypotheses, further work is needed to better understand the relationship between student stress and fatigue and low engagement with asynchronous resources.

Examining voluntary survey responses demonstrated that students had generally neutral to positive perceptions of the virtual laboratories which did not change significantly (>10%) in either lab or between their expectations going into the laboratories and after experiencing the lab. This suggests that despite the challenging situation students find themselves in given the COVID-19 pandemic and working remotely, they are trying to make the best of their education. The one exception to this general positivity is their perception of losing out on hands-on experience which saw a notable increase (31.4%) after experiencing the virtual form of normally highly interactive hands-on labs. Students did show a noticeable gravitation towards the interactive and stylized asynchronous video "Cooking with Concrete" and support its use as a supplementary resource for future course offerings. A further interest with visual media formats was revealed when students were asked about their preference between a written and video submission for a lab report. The most common reason for this preference was the ability to express their creativity as well as the medium being viewed as more fun and enjoyable. The authors would suggest that educators continue to incorporate visual medias to allow students a creative and at times enjoyable form of expression. This is especially important when students are spending a significant time in front of screens, and such a chance to be the ones behind the camera can provide a break.

The authors acknowledge that the current breadth of the study is limited to a single course within Civil Engineering which can limit its applicability to all forms of engineering. However, the insights gained should prompt similar research in the future to examine if results differ in non-COVID years and in different demographics, be it institution, discipline of engineering, year, and class size. Additionally, as courses will often vary in their incorporation of experiential learning components such as laboratories it would be of use to see student perception in more theoretical or soft-skill oriented courses.

This study outlined the differences between student engagement with synchronous and asynchronous course elements, highlighting the benefits and drawbacks to each. These findings can inform the design of similar courses, both in person and virtual, to capitalize on the successes noted and in preparing to address the challenges.

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Appendix A: SURVEYS

A.1 Pre-Lab Modified MLLI Survey

Students were asked to assess each item against a Likert scale. When performing labs in this course, I expect…

Q1. to learn materials properties that will be useful in my career.
Q2. to learn critical thinking skills.
Q3. be excited to pursue civil engineering.
Q4. to develop confidence in future use of the structures laboratory.
Q5. to learn about the underlying concepts.
Q6. to interpret my data beyond only doing calculations.
We use this statement namely for quality verification and to test the survey for accurate entry cataloguing. Please select both 1 and 5 (this is the only question where you should choose more than one option).
Q7. to focus on procedures, not concepts.
Q8. to be intrigued by the equipment.
Q9. to learn problem solving skills.
Q10. to have greater confidence in skills built through hands on mentorship.
Q11. to be losing out due to lack of on hands on lab experience.

A.2 Lab 1 and Lab 2 Surveys

The same questions were used for both Lab 1 and Lab 2 surveys. Note that the quality assurance question displayed is for the Lab 1 survey, for the Lab 2 survey the students were asked to click options 1 and 3. Students were asked to assess each item against a Likert scale.

Q1. The lab was useful.
Q2. The lab was easy to follow
Q3. I am confident in my ability to complete the lab in person, given the chance.
We use this statement namely for quality verification and to test the survey for accurate entry cataloguing. Please select both 2 and 4 (this is the only question where you should choose more than one option).
Q4. I am confident that I have learned the concepts involved in this lab.
Q6. I feel I am able to apply the concepts I learned to meet the challenges of the course.
Q7. The lab was a suitable replacement for physical labs.
Q8. The lab video "Cooking with Concrete" would be valuable to future students as a pre-lab supplement (Lab 2 only)

A.3 Post-Lab Modified MLLI Survey

Students were asked to assess each item against a Likert scale. When performing labs in this course, I …

Q1. learned materials properties that will be useful in my career.
Q2. learned critical thinking skills.
Q3. am excited to pursue civil engineering.
Q4. developed confidence in future use of the structures laboratory.
Q5. learned about the underlying concepts.
Q6. interpreted my data beyond only doing calculations.
Q7. focused on procedures, not concepts.
Q8. was intrigued by the equipment.
Q9. learned problem solving skills.
Q10. have greater confidence in skills built through hands on mentorship.
We use this statement namely for quality verification and to test the survey for accurate entry cataloguing. Please select both 4 and 5 (this is the only question where you should choose more than one option).
Q12. lost out due to lack of on hands on lab experience.
The following questions did not use a Likert scale.
Q13. Which lab did you find was more useful: Lab 1 - Structural and Material Properties of Steel or Lab 2-Concrete Lab?
Q14. Why did you find the lab you selected in Question 13 more useful?
Q15. Which lab did you find had the more effective delivery method: Lab 1-Structural and Material Properties of Steel or Lab 2-Concrete Lab?
Q16. Why did you find the lab you selected in Question 15 more effective?
Q17. Did you prefer making a video or written lab report?
Q18. Why did you prefer the format of lab report chosen in Question 17?
Q19. Would you like to have more opportunities in future courses to submit reports in a video format?