# Student Perspectives of Online Teaching: Lessons Learned for the Post-Covid Classroom

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## Abstract

As instructors return to in-person teaching and learning following online teaching during the COVID-19 pandemic, we can build from the experiences gained and incorporate various online resources into our campus-based classes. Drawing from student evaluations of teaching, a post-course student survey and learning management system (LMS) analytics, we documented students' perspectives of online teaching and learning in a large introductory science course offered as a flipped classroom, and reflect on student and instructor perspectives as we return to campus-based teaching and learning. Results suggest that what students liked and what they perceived as effective often did not align, and that instructors need to consider good pedagogical practice when evaluating student comments. We identified strategies that we can carry forward to enhance our large introductory science course including a weekly course structure, synchronous classes and laboratories supported by asynchronous content, and taking advantage of recent advancements in online teaching and learning tools for discussion forums, practice exams and assessment.

*Keywords:* soil science, on-campus education, online education, undergraduate education

In the spring of 2020, the COVID-19 pandemic necessitated emergency remote teaching at universities and colleges around the world. Instructors rapidly pre-recorded lectures, cancelled laboratories, created online assignments and developed alternative final exam formats (Gacs et al., 2020). In planning for the 2020-21 academic year, which followed the initial emergency remote teaching, many postsecondary instructors were still faced with a shift in course delivery, requiring that campus-based courses be restructured to an online format (Hodges et al., 2020). The preparation window for this transformation was narrow and required that the planning, preparation and development of online courses be collapsed into a single step. Instructors scrambled to incorporate both synchronous and asynchronous components into their courses in an attempt to engage students while simultaneously providing flexibility (Banack et al., 2020).

Flipped teaching was one instructional approach employed during the pandemic. In a flipped teaching format, concepts are introduced prior to class, typically through readings or pre-recorded videos, allowing the instructor to use class time to guide students through active, practical applications of the course content (Keck et al., 2021; Marshall and Kostk, 2020). The flipped format aligned with providing both asynchronous and synchronous content, but instructors had to reconfigure learning activities for the online environment (Beason-Abmayr et al., 2021; Brown and Krzic, 2021). In this format, students take on greater responsibility for their learning, but inadequate student preparation prior to class can be a major limitation of flipped teaching and learning (Akcayir and Akcayir, 2018).

Adapting hands-on experiences such as laboratories in the online environment were particularly challenging. Instructors created online laboratory alternatives using workbooks, videos of laboratory methods, data files, and take-home field kits. By necessity, laboratories shifted their emphasis from precise experimental techniques to data analysis and problem solving (Delgado et al., 2021). While post-course student surveys indicated a preference for in-person field experiences over remote delivery options (Aleman et al., 2021), instructors recognized the potential to utilize virtual learning resources to complement on-campus labs (Brevik et al., 2021).

Providing meaningful learning experiences to first and second year students in a large online course created additional challenges. Novice learners may lack time management and self-regulated study skills, which have been linked to students' abilities to adjust to online learning during the COVID-19 pandemic (Eberle et al., 2021).

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Instructors have sought to provide structure for students through weekly assignments or regular online quizzes. However, this shift in assessment resulted in increased workloads for many students (Motz et al., 2021).

Student engagement has been found to enhance student motivation and performance in online courses. This includes interactions of online learners with content, instructors and peers (Martin and Bolliger, 2018). A range of strategies were employed by instructors during the pandemic in an attempt to engage learners including extensive video recording (Culbert, 2021), podcasts (Strickland et al., 2021), online polls, chats and breakout group discussions (Tice et al., 2021). During the emergency remote teaching period of the pandemic, students indicated a preference for synchronous online activities (Nguyen et al., 2021). In the following academic year many higher education institutions remained fully online, and instructors moved to a hybrid approach attempting to find a balance between synchronous and asynchronous modes of instruction (Zhou and Chen, 2020).

In this study, we focus on the academic year following the emergency transition to online teaching. Our objectives were to: (1) document students' perspectives of online teaching and learning in a large introductory science course offered as a flipped classroom and (2) reflect on student and instructor perspectives as we return to campus-based teaching and learning.

## Materials and Methods

### Course overview

The Introduction to Soil Science course offered at a research-intensive university is a foundational soil science course for students enrolled in programs in several Faculties including Forestry, Land and Food Systems, and Science. The course has been offered annually since its introduction in 1955, and as a service course for several programs it has historically had a relatively large enrollment of predominantly first year students. Traditionally, the Introduction to Soil Science course at the University of British Columbia has been offered on-campus as a lecture-based theory course with a laboratory component. This is a typical format for this type of course in Canada, as a recent survey of introductory soil science courses at Canadian postsecondary institutions has shown that 93% of those courses are offered as campus-based (Krzic et al., 2018).

Following the onset of the COVID-19 pandemic in March 2020 and subsequent rapid transition to emergency online teaching and learning, in the 2020/21 academic year, our introduction to soil science course was transitioned to an online course and offered as a flipped classroom. It blended asynchronous learning focused on the text-based content with synchronous online classes, laboratories and office hours.

The text-based content in the learning management system (LMS) was organized into weekly modules (n=13). Each module included content material for that particular week, supplemental readings, and an assignment (Fig. 1). To complement the asynchronous text-based content, weekly synchronous (live) classes of 50 minutes were scheduled on Fridays (Fig. 1). Prior to those synchronous classes, students were asked to review the online content. During the weekly synchronous class, the instructor reviewed core content and used in-class anonymous polling to focus on challenging concepts, so called "muddy points" (Carberry et al., 2013). Through the combination of synchronous and asynchronous sessions, we aimed to enhance teaching presence, optimize student time focused on course material, accommodate students in different time zones, and maximize student learning in the online environment (Guo, 2020; Marshall and Kostka, 2020).

Online laboratories were also revised by removing videos heavily focused on laboratory and field procedures, and replacing them with newly created videos showing key concepts and data interpretation. Several new videos were produced and we also incorporated some existing video clips developed by the Canadian Virtual Soil Science Learning Resources group (https://soilweb.ca/). Similar to the traditional, campus-based version of this course, each of the ten synchronous laboratory sections (with about 30 students) were led by an instructor or teaching assistant. Weekly teaching team meetings were led by the course instructors, and teaching assistants were provided with lesson plans and detailed marking notes for each week. During online laboratories students were provided a workbook with several questions related to the readings of that week, students were randomly divided into small groups (5 to 6 students each), each team was assigned one question from the workbook and given time to work collaboratively in breakout group sessions on their

**Figure 1.**

*Weekly student schedule indicating asynchronous and synchronous (live) activities in the Introduction to Soil Science course offered online during 2020/21 academic year.*

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|
| Asynchronous | Synchronous Lab/Office hour[z] | Asynchronous | No activity | Synchronous class | No activity | Assignment due |

**Note.** [z]Synchronous lab / office hour times vary by lab section. Individual lab / office hour times may be on Monday, Tuesday, Wednesday, or Thursday depending on student schedules question. In plenary, the teams presented their responses, and an instructor or teaching assistant guided the discussion. These workbooks were not graded, but were intended to engage students with the content of a particular week. These online synchronous laboratory sessions also provided opportunities to answer questions from students, thereby also serving as synchronous office hours.

In addition to synchronous class and laboratory/office hours, instructors monitored an asynchronous discussion forum in the LMS. Students could post questions and answer questions of their colleagues; instructors monitored and responded daily. The anytime / anywhere format of the asynchronous discussion has been successfully used in our on-campus course since 2013. Our experience was aligned with research findings that asynchronous, computer mediated communication, in addition to synchronous communication, provides flexibility for students, and enhances teacher-student and student-student interactions (Johnson, 2006; Li et al., 2010).

Supplemental to the text-based content in the LMS, we used the same textbook (Weil and Brady, 2019) as the campus-based version of this course. Research on textbook usage and student performance is mixed, but studies suggest that some students may need to read the textbook "often" to do well (French et al., 2015; Landrum et al., 2012). As of the 2021/22 academic year, we are planning to also incorporate readings from the Canadian-based, open access textbook (https://openpress.usask.ca/soilscience/), developed by more than 40 members of the Canadian Society of Soil Science (Krzic et al., 2021).

Student assessment was based on assignments, and midterm and final exams. Assignments were posted on the LMS. Students upload their assignments, and teaching assistants, under the supervision of instructors, provided written feedback through a rubric incorporated in the online grading system. These assignments mimicked the style of questions on the exams (e.g., short answer, compare and contrast questions, multiple answer questions). An honesty pledge was added to each assignment, where students affirm that "all answers are written in their own words".

In line with the analysis of Dadashzadeh (2020), the weighting of course components was put more towards assignments (60%), while the midterm exam contributed 15% and final exam 25%. Invigilation of exams has proven to be controversial in the fully online environment (Coghlan et al., 2020). Lockdown and remote proctoring software have high bandwidth requirements, are considered invasive by some students, and may not be available in certain countries (e.g., where the use of virtual private network - VPN software is prohibited). Consequently, we decided to move to open-book online exams, administered through our LMS. Midterm and final exams were a mix of short answer and quiz style questions, which were drawn randomly from a series of question banks, and were time limited. Exam questions were randomly selected using the quiz settings within the LMS so that each student received a different combination of questions on their exam. The honesty pledge attached to the assignments was also included at the beginning of the exam. In addition, a practice exam was posted in the LMS. It used the same format and number of questions, allowing students to become familiar with the online editor and the timing of the exam. This approach was in line with research that has shown formative assessments (such as practice exams) lead to enhanced learning and retention (Roediger and Karpicke, 2006). We chose to minimize the repetition of questions between the practice exam and the actual exam, by using a subset of questions within the question banks. Time zone accommodation was provided to students based on academic hardship recommendations from the University's Centre for Accessibility.

**Table 1.**

*Data sources and survey response rates obtained during 2020/21 academic year for the Introduction to Soil Science course; enrolment 273 students.*

| Data Set | Number of responses | Response rate (%) |
|---|---|---|
| Student evaluations of teaching (SEoT) | 127 | 47 |
| Post-course student survey | 74 | 27 |
| LMS[z] (Canvas) analytics | 273 | n.a. |

***Note.*** [z]Learning management system

## Evaluation

In the 2020/21 academic year, there were 273 students in our course with 78.0% of them in the 1st year of their study, 16.5% in 2nd year, 4.4% in 3rd year, and 1.1% in 4th year; which is typical for this course. Three datasets were utilized to gain insight into students' perspectives and their online activity during the course. Specifically: 1) Student evaluation of teaching (SEoT) survey, administered by the university at the end of classes; 2) Post-course student survey, developed and administered by the instructors following the final exam period (after grades were released); and 3) Data analytics from the course LMS (Canvas, Instructure Inc. at our university).

The SEoT survey focused on students' perceptions of the instructor and the course in general. The survey contained a combination of Likert scale questions and open ended feedback. The Likert scale questions were on a five point scale ranging from 1 (strongly disagree) to 5 (strongly agree) and focused on students' perceptions of the effectiveness of the instructor. Open ended questions asked what students liked most about the course and their perspective on how the course could be improved. Of the 273 students enrolled in the course, 47% responded to the SEoT survey (Table 1).

The post-course survey focused on students' perspectives of the effectiveness of the online content, synchronous classes, online laboratory/office hours, and the asynchronous discussion forum in supporting their online learning. This survey contained a combination of categorical questions, Likert scale questions, and open ended feedback. Categorical questions asked how often students read course materials, attended synchronous classes and online laboratory/office hours, and utilized the asynchronous discussion forum. Likert scale questions were on a five point scale ranging from 1 (strongly disagree) to 5 (strongly agree) and focused on students' perceptions of the effectiveness of specific components within the online content, synchronous classes, online laboratory/ office hours, and asynchronous discussions. Open ended questions asked students' their perspective on the most effective strategies used to engage students, and what could have been done differently. Of the 273 students enrolled in the course, 27% responded to the post-course survey (Table 1).

Student responses to Likert scale questions were summarized based on frequency analysis and the tabulation of interpolated median, dispersion index and percent favorable. As Likert scale questions provide ordinal (ranked) data, central tendency was represented by the interpolated median, which adjusts the median based on the number of responses above and below the median value (Hassler, 2020). The dispersion index (DI) was used to provide a measure of variability suitable for ordinal data (Rampichini et al., 2004). A value of DI=0 indicates that all students gave the same rating; while a DI=1.0 indicates an even split between the two extremes (strongly agree and strongly disagree). Percentage favorable corresponds to the number of responses in the agree or strongly agree categories. Pearson's chi-squared test was used to determine differences in Likert scale responses based on participation in course activities. Computer aided content analysis was used to analyze open ended questions (Krippendorff, 2012). Descriptive codes were manually generated from the responses using an inductive approach (Linneberg and Korsgaard, 2019), and the number of responses per code were tabulated using NVivo© qualitative analysis software (QSR International, Melbourne, Australia).

The learning analytics data provided by the course LMS included a summary of page views, online participation and weekly trends. Page views were tabulated by module, and included the percentage of students and the number of views per student for content pages, virtual labs and self-study questions. Participation with online content included the submission of assignments, downloading ungraded workbooks, and the number of times students attempted practice exams.

Differences in responses between the two surveys reflect the fact that different questions were asked, but also the timing of the two surveys. Multiple surveys have been reported to result in survey fatigue and lower response rates (Porter et al., 2004). The SEoT survey conducted by the university occurs at the end of classes, prior to final exams, and was a time of high stress for many students, particularly after two terms of fully online classes during the COVID-19 pandemic. The post-course survey, in contrast, was available for the two weeks after the exam period, and gave students time to reflect.

## Results and Discussion

### What students liked versus what they perceived as effective

Respondents to the SEoT survey identified that interactions with their instructor and synchronous classes were the components of the course that they "liked the most" (Table 2). Ninety-one percent of respondents participating in the SEoT survey agreed or strongly agreed that the instructor was an effective teacher (data not shown). Students' comments reflect both engagement and the utility of synchronous classes, which required students to practice retrieving prior knowledge: "I really enjoyed how the lectures were focused around participation through recollection of the course content" and "….the instructor was always very patient and re–iterated key concepts during lectures." Retrieving or attempting to retrieve knowledge from memory has been demonstrated to enhance learning (Karpicke and Blunt, 2011), and our online course incorporated this technique. While students indicated a preference for synchronous classes, 10% commented that they "liked" having access to the asynchronous online content in the course LMS.

The post-course survey was more specific than the SEoT, and asked students to reflect on "the most effective strategy" to engage them as an online learner. While there were similarities to the SEoT responses, the most commonly mentioned components were different. Asynchronous online content in the course LMS was identified as the most effective strategy by 30% of respondents (Table 2). Online laboratories, synchronous classes and weekly assignments were identified as effective strategies by 24 to 25% of respondents. Some students specifically mentioned the combination of components.

> Breaking up readings into digestible chunks (i.e. several pages per module), mixing asynchronous content with synchronous content (Office Hours and Friday sessions), and providing ample opportunity for feedback and answers to questions (returning assignments quickly, posting quick responses to discussion board posts) were very helpful for engaging me as an online learner.

Asynchronous online content was viewed both positively and negatively by students in this large introductory science course. Students recognized the flexibility of "being able to read the content anytime", and that the online notes were "detailed and well organized", so that it "was very easy to study". However, 10% of students indicated that they struggled with the amount of reading and self-study, reflected in comments such as "the note sections were long and time consuming". Studies report that fewer than 25% of first and second year students complete assigned readings (Burchfield and Sappington, 2000), and that the top reason students cited for not reading was a schedule that did not allow time for reading (Hoeft, 2012). In our introductory soil science course, we specifically allocated time for reading by scheduling two asynchronous sessions per week (Fig. 1). In this manner, students worked at their own pace, but flexibility was contained within a structured framework

**Table 2.**

*What students liked versus what they perceived as effective in the Introduction to Soil Science course, offered online during 2020/21 academic year; based on open ended questions in student evaluation of teaching (SEoT) and post-course surveys.*

| Strategy | Responses (%) | |
|---|---|---|
| | What I liked most about this course was …[z] | What was the most effective strategy to engage you as an online learner[y] |
| Instructor was enthusiastic and engaging | 29 | - |
| Synchronous classes | 16 | 24 |
| Weekly course structure | 12 | 19 |
| Asynchronous, online content in LMS[x] | 10 | 30 |
| Weekly assignments | 9 | 24 |
| Instructor willing to answer questions | 8 | 7 |
| Instructor clearly explained concepts | 7 | - |
| Online laboratory / breakout group sessions | 6 | 25 |
| Self-study questions | 2 | 7 |
| The combination of components | 2 | 7 |
| Videos | 1 | 9 |

***Note.*** [z]Student evaluation of teaching (SEoT) survey (n=97). [y]Post-course survey (n=74). [x]Learning management system.

(Hendrickson et al., 2021).

Online laboratories, which included breakout group sessions, ranked very differently in the two surveys, with only 6% of respondents in SEoT survey indicating they "liked" these sessions, while 25% indicated they were effective in supporting their learning. Retrieval practice between peers (sometimes referred to as peer-to-peer learning) has been demonstrated to enhance learning as students must organize information in such a way that they are able to verbally articulate it to others (Stigmar, 2016). However, this type of learning may be better suited to more experienced learners (i.e., students in later years of their study), while 78% of students in our course were novice learners in their first year of university. Research indicates that novice learners required more guidance in their learning compared to upper level undergraduates (Kirschner et al., 2006).

The weekly course structure with weekly assignments was perceived as moderately effective in engaging students and supporting their learning as illustrated by this feedback statement:

> I liked how efficiently the information was given to us in the weekly modules, clearly outlining what we needed to know. The weekly assignments also helped me develop a sense of what key things I needed to know as well as types of questions to expect on exams.

Course designers stress the need for consistency in structuring online courses. Chunking content and organizing content in a modular or weekly structure is recommended to provide students a roadmap of the course (Martin et al., 2019). A straightforward course structure is particularly important in lower-level online courses. Weekly assignments help to engage students with the weekly content and allows instructors to track progress (Cicco, 2015). While students did not identify the course organization as highly effective, they did recognize that "the organization and what was expected of us was really well organized", and that the "weekly assignments were a great tool to solidify the week's content."

The effectiveness of the weekly course structure with weekly assignments was supported by the course LMS analytics, which showed consistent and high participation on graded assignments (Fig. 2). Note, however, that the downloading of ungraded workbooks used during the online laboratories decreased to as low as 40% of students. This suggests that at times up to 60% of students were motivated by graded work alone, and did not recognize the value of the online laboratories that included activities similar to their assignments.

Our emphasis on weekly assignments aimed to encourage students to interact with the online content on a regular basis. Due to the sequential nature of the course content, ongoing assessments were essential (Cicco, 2015), and was reflected in comments from students such as:

> The grading distribution with heavier weighting on weekly assignments was really effective for me. I was able to practice the material every week, and both understood and remembered the content better than with courses where I am just memorizing for the midterms/finals.

Weighting the final exam at 25% was deliberate, reflected the cumulative nature of the course material, and was substantive enough to allow for grade improvement.

This was in agreement with findings of Franke (2018) who found that lower stake final exams (5 to 15%) made little difference to students' final grades, a final exam worth 25 to 30% provided the opportunity for students to reach the next higher letter grade, and that more heavily weighted exams had diminishing effects.

### Are unedited recordings of synchronous classes the answer?

Both synchronous and asynchronous components were viewed as effective by students (Table 2), and as an area that could be improved (Table 3), with 10 to 15% of respondents suggesting no change. In both surveys students sought greater interaction with their instructors suggesting "slightly less self-study and slightly more synchronous lecture time". In hindsight, both instructors agreed that the having two synchronous classes per week (e.g., Monday and Friday) would have been prudent. Students also expressed a desire to have synchronous classes recorded and/or more videos and pre-recorded lectures embedded within the online content (Table 3). Research supports the segmenting of pre-recording lectures, focused on concepts that student have difficulty comprehending (Guo et al., 2014; Mayer, 2017).

**Figure 2.**

*Student completion of graded assignments versus ungraded workbooks in the Introduction to Soil Science course, offered online during 2020/21 academic year; based on learning management system (LMS) analytics.*

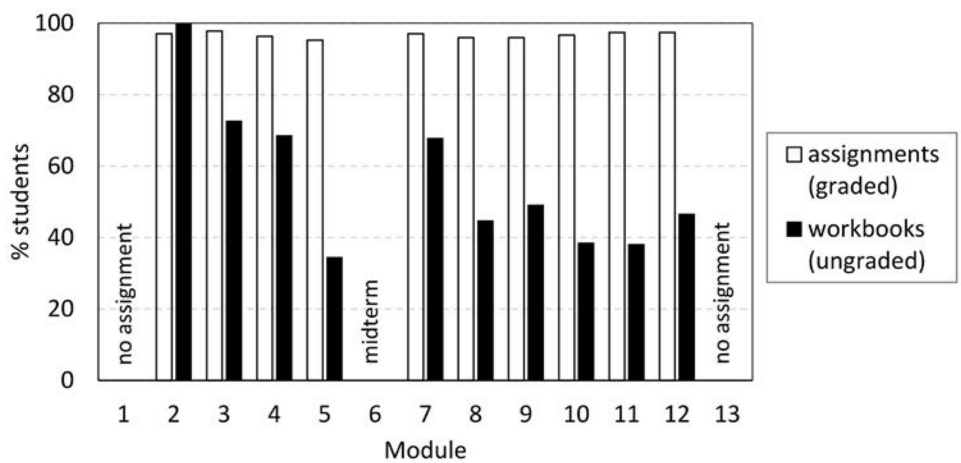



**Table 3.**

*Students' suggestions to improve the Introduction to Soil Science course, offered online during 2020/21 academic year; based on open ended questions in student evaluation of teaching (SEoT) and post-course surveys.*

| Item | Responses (%) | |
|---|---|---|
| | I suggest the course could be improved by …[z] | What could have been done differently to engage you as an online learner[y] |
| Record synchronous classes | 21 | 34 |
| More synchronous lectures | 18 | 34 |
| Nothing | 10 | 15 |
| Changes to grade allocation | 7 | - |
| More videos within online content | 6 | 7 |
| More practice quizzes | 4 | 3 |
| Pre-record lectures | 3 | 3 |
| Accommodate time zone differences | 3 | 5 |
| Additional feedback on assignments | 1 | 3 |
| Mandatory participation | - | 4 |

***Note.*** [z]Student evaluation of teaching (SEoT) (n=87). [y]Post-course survey (=74).

The recording of live classes and posting unedited class recordings, on the other hand, has potential disadvantages. Posting long unedited class recordings increase cognitive load, often contain extraneous information and do not effectively engage students. In contrast, brief, focused videos may reduce extraneous load and increase the percentage of videos that students watch (Brame, 2016). Recordings of live classes contain redundant information, which could be excluded, and privacy concerns mean that interactive components of a course cannot be recorded without written consent from students. The contradiction between what students want (recordings of live classes) versus good pedagogical practice (e.g., chunking and reduced cognitive load) could be resolved by pre-recording and posting additional "mini-lectures" in combination with text-based notes in the course LMS (Hendrickson et al., 2021). Note that not all students in our study supported recording live classes: "Having concise readings to learn from opposed to videos was amazing. The information is all in front of you and easy to reference and take notes on."

### Student-instructor versus peer-to-peer teaching and learning

Interactions with instructors in synchronous classes and laboratory/office hours were perceived by students as effective in supporting their learning, while interactions with peers were viewed less favorably (Table 4). Answering questions in the small group sessions (i.e., during online laboratories/office hours) was identified as effective by 93% of respondents. Students' preference to ask questions in a small group setting (n=30) aligns with studies that found that 50% (or more) of students never ask or answer questions in large classes (Nadile et al., 2021). While interaction with instructors and teaching assistants during online laboratories/office hours was viewed as effective, breakout group activities and working with other students were not perceived as highly effective (receiving 67% and 60% favorable ratings, respectively). Research suggests that students with lower achievement perceived non-mandatory peer-instruction sessions as boring, complicated or confusing, while students with higher academic achievement perceived them as interesting and motivating (Budini et al., 2019). Furthermore, attendance in breakout sessions has been found to be a key predictor of student achievement (Blackstone and Oldmixon, 2016). While we did not formally track attendance in our course, instructors and teaching assistants observed that a subset of students consistently attended online laboratories/office hours.

The review of concepts by instructors during synchronous classes had the second most favorable ranking at 84% indicating that students recognized the importance of effective online teaching in supporting their learning. Since the format of this course was flipped, with students pre-reading materials, we were able to focus on core content during synchronous classes (Mayer et al., 2001), and as instructors with more than 40 years of combined teaching experience, we were able to anticipate concepts which students find challenging, and incorporate that material (Carberry et al., 2013). Interactive components such as polls and responding to questions in the online chat were viewed by students as subsidiary to the presentation of key concepts by instructors, but were likely important for engagement (Walker et al., 2021).

### Engaging students with asynchronous online course content

Our approach to engaging students with online content was multi-faceted, incorporating readings, weekly assignments, practice exams, and asynchronous discussion forums. In a typical week, 32% of respondents to the post-course survey reported reading the online course content four times per week or more; 61% accessed online content two to three times per week, while the remaining 7% logged in once per week (Fig. 3). The 61% of respondents who read online content two to three times per week would be undertaking the equivalent of our traditional three classes per week structure for in-person course delivery, while those 32% who accessed the readings more often were

**Table 4.**

*Student perceptions of activities during synchronous classes and laboratories in the Introduction to Soil Science course, offered online during 2020/21 academic year; based on responses to the post-course survey (Likert scale questions, n=74)*

| Item | Session | Interpolated median | Dispersion index | % favorable |
|---|---|---|---|---|
| Answering questions during breakout group sessions | Online lab | 4.80 | 0.10 | 93 |
| Review of concepts from LMS[z], highlighting key points | Synchronous class | 4.14 | 0.14 | 84 |
| Polls, annotating slides, rebus puzzles | Synchronous class | 4.07 | 0.17 | 75 |
| Responding to questions posted in the chat | Synchronous class | 4.07 | 0.21 | 72 |
| Breakout group activities during virtual lab/office hours | Online lab | 3.94 | 0.28 | 67 |
| Staying at the end of virtual class to answer questions | Synchronous class | 3.99 | 0.26 | 66 |
| Working with other students during breakout groups | Online lab | 3.92 | 0.36 | 60 |

***Note.*** [z]Learning management system. Likert scale ranging from 1 (not effective) to 5 (extremely effective). Online laboratories/office hours, about 30 students per section. Synchronous class, total of 273 students enrolled.

potentially studying and reviewing content on an ongoing basis. These results align with Amiel and Orey (2007) who used student log data to compare online and in-person courses and found that on average, total time spent over the term was similar for those two modes of course delivery.

Course analytics indicated that the students viewed content pages multiple times per weekly module, reflecting their initial reading, review of concepts to answer questions on weekly assignments, and studying for midterm and final exams (Fig. 4). Students viewed content pages an average of 8.5 times per page. In general, students' reading of content posted in the course LMS tailed off towards the end of term. Note, however, that content varied in complexity and length between weekly modules, thus impacting the number of page views for a specific module.

Students perceived visual formats as the most effective strategy to engage them with online content (86% favorable, Table 5). While the text-based course readings ranked as moderately effective (72% favorable), students recognized the utility of the text-based content, as reflected in comments such as "the instructors compiled all the info we needed to learn on Canvas, it made it much easier to read the content and less expensive as we were not required to buy a textbook." Students' preference for visual formats aligns with the multimedia principle that the combination of text and graphics (rather than text alone) support learning in the online environment (Mayer, 2017).

Practice exams were viewed as effective in supporting student learning (80% favorable, Table 5). Eighty to eighty-four percent of students accessed the practice exams (Table 6). Younger students, in particular, have shown improved exam performance if they participated in practice exams (Cummings, 2020). Our practice exams, mimicked the format and style of the actual exams, thus providing students with familiarity with the type of questions and the timing of the exam. On average, there were 3.3 attempts per student on the practice midterm exam and 9.4 attempts on the practice final exam (Table 6). Research on the effects of

**Figure 3.**

*Frequency of reading online course content as reported by students in the Introduction to Soil Science course, offered online during 2020/21 academic year; based on responses to the post-course survey.*

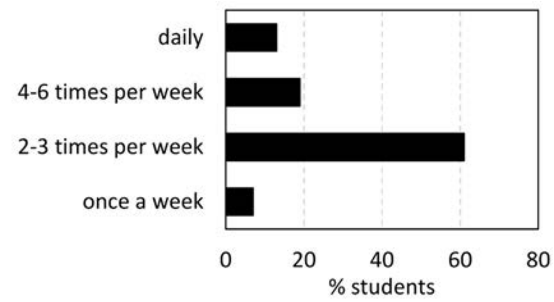



**Figure 4.**

*Student views of learning management system (LMS) content per weekly module in the Introduction to Soil Science course, offered online during 2020/21 academic year; based on LMS analytics.*

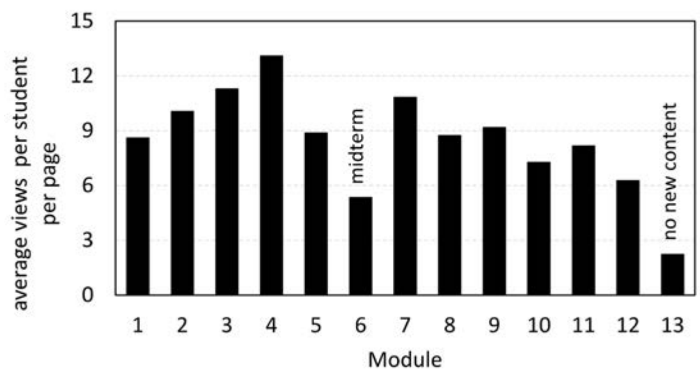



**Table 5.**

*Strategies to engage students with content in the Learning Management System (LMS) of the Introduction to Soil Science course, offered online during 2020/21 academic year; based on post-course survey (n=74).*

| LMS | Interpolated median | Dispersion index | % favorable |
|---|---|---|---|
| Photos, graphics and videos | 4.16 | 0.15 | 86 |
| Practice exams | 4.14 | 0.22 | 80 |
| Timely feedback on assignments | 4.12 | 0.22 | 77 |
| Text-based course reading material | 4.07 | 0.29 | 72 |
| Grading rubrics for assignments | 3.98 | 0.29 | 62 |
| Online discussion forum | 3.97 | 0.32 | 59 |
| Self-study questions | 3.92 | 0.28 | 58 |
| Module overviews | 3.91 | 0.27 | 58 |
| Course roadmap | 3.18 | 0.30 | 49 |

***Note.*** Likert scale ranging from 1 (not effective) to 5 (extremely effective)

**Table 6.**

*Student use of practice exams in the Introduction to Soil Science course, offered online during 2020/21 academic year; based on learning management system (LMS) analytics.*

| | % students attempting practice exams | Average number of attempts |
|---|---|---|
| Practice midterm exam | 84 | 3.3 |
| Practice final exam | 80 | 9.4 |

multiple attempts on practice exams have shown improved student performance on summative exams (Davis et al., 2020).

Timely feedback on assignments and the use of grading rubrics, were perceived by students as moderately effective (77% and 62% favorable, respectively, Table 5). In a large introductory science course with multiple teaching assistants involved in marking assignments, a clear rubric, and weekly marking meetings were viewed by the instructors as essential to ensure consistent marking. Studies on the use of rubrics (Cockett and Jackson, 2018), support that both instructors and students viewed rubrics as a method to enhance consistency in assessment.

The online discussion forum was viewed by students as moderately effective (59% favorable, Table 5). Research suggests that students' viewed peer-to-peer discussion forums as the least helpful instructional activity in online classes (Jayaratne and Moore, 2017). However, the discussion forum in our course was a not typical peer-to-peer discussion, but functioned as a question and answer forum monitored by instructors. Students were most active on the asynchronous, online discussion forum at the very beginning of term posting general course questions, and the weeks of the midterm and final exams (Fig. 5). The asynchronous nature of this forum provided students an additional avenue to ask questions.

> I liked most about this course was students can post their question under discussion section, and then the instructor can reply comments. If other students have the same questions, then they can easily know what happened and follow up with the questions.

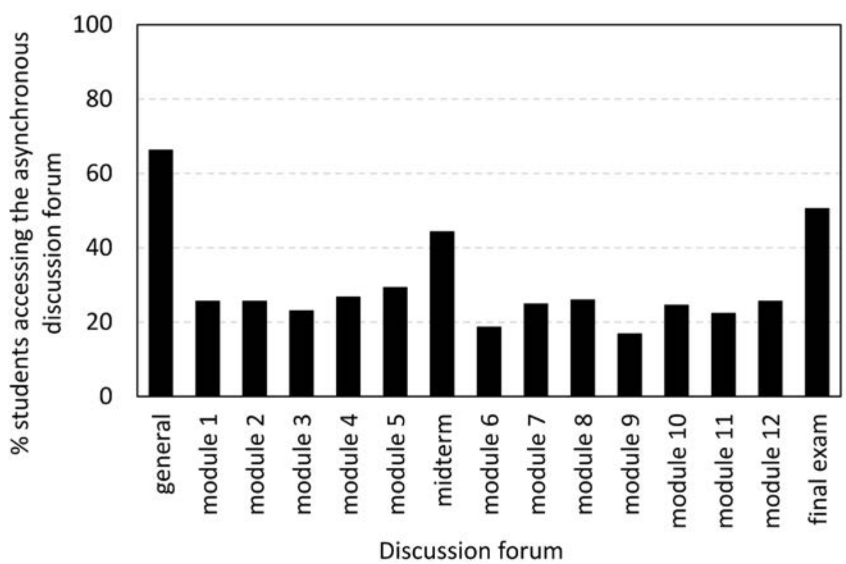
Posting questions in the online discussion forum was not anonymous, which might have deterred some students from posting. Anonymous forums have been shown to have a higher number of students posting (Roberts and Rajah-Kanagasabai, 2013). However, we opted not to have our discussion forum anonymous since we wanted students to be accountable for the questions that they posted. In a large course, mainly attended by first year students having an anonymous forum may lead to an excessive number of posts.

## Lessons learned to implement as we return to campus

Having offered our course in the online setting has allowed us to reflect on the strategies used to enhance student learning and engagement. As we go back to offering this large introductory course through in-person classes and laboratories, the lessons learned from teaching and learning during the pandemic will guide our implementation. First, we will keep the weekly module type of organization of the course material in the LMS. Students liked this streamlined organization in the online version of our course and commented that it helped them navigate through the

**Figure 5.**

*Student use of the asynchronous online discussion forum in the Introduction to Soil Science course, offered online during 2020/21 academic year; based on learning management system (LMS) analytics.*



course material and weekly assignments. Also, having weekly assignments, which incorporate both theoretical concepts (covered in classes) and practical applications of those concepts (covered in laboratories), contributed to better alignment with course learning outcomes; hence, we will continue to utilize this weekly structure moving forward. Second, during the 2020/21 academic year, we made an effort to devise detailed course notes, which represented required reading for our students. That material was posted in the LMS together with references to supplemental reading material, and we are planning to keep that for future offerings of this introductory course. The only change will include addition of certain chapters from the open Canadian textbook (https://openpress.usask.ca/soilscience/) to the supplemental reading list. Third, we will adjust in-person laboratory sessions to have a greater focus on concepts and data interpretation, instead of being focused on procedural details of laboratory analysis and soil description. This will be accomplished by incorporating group tasks from our virtual laboratory workbooks into our in-person laboratory sessions. We hope that having a combination of hands-on activities with some in-person group discussion will result in better student engagement with course material as well as with other students. The latter is of a great importance in large courses such as ours that generally offer limited opportunities for student interactions with their peers. Fourth, we will continue to use the asynchronous discussion forum in the LMS, since this provides an important, additional avenue of communication between students and instructors as well as among students themselves. Enhancement of communication is of particular importance in large courses; hence, proven opportunities such as LMS discussion forums should be incorporated. Fifth, we will continue to develop additional short videos focused on challenging concepts to supplement required reading material already posted in the LMS. From an instructor perspective, we aim to find a balance between text-based content, and video and other graphical formats. Sixth, creation of the question banks and random selection of questions from those question banks in online exams allowed us to avoid proctoring software during our online exams in 2020/21 academic year. Moving forward to in-person mode of teaching and learning we plan to continue to enhance the existing question banks and to continue to use them in online midterm exams.

## Summary

Although the transition to online teaching and learning during the pandemic offered only a very narrow preparation window, it presented course instructors with valuable opportunities to re-evaluate their courses and embark on development of a range of online educational resources. Moving forward to either in-person, online or hybrid modes of course delivery, requires that we reflect and evaluate what has been done since the beginning of the pandemic in March 2020, so that our students can benefit from what we have learned during this unprecedented time.

Student perspectives helped to guide our reflection, but what students indicated they wanted and what is known to be pedagogically effective may not always align. Drawing from both student and instructor perspectives allowed us to identify strategies from teaching online during the COVID-19 pandemic that we can carry forward to enhance our large introductory science course as we move back to in-person teaching and learning. Our assessment highlights the utility of a weekly course structure, synchronous classes and laboratories supported by asynchronous content, and taking advantage of recent advancements in online teaching and learning tools for discussion forums, practice exams, and assessment.

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