Lessons learned teaching during the COVID-19 pandemic: Incorporating change for future large science courses

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Abstract
Due to the COVID-19 pandemic we were confronted with the transition of a large, on-campus introductory soil science course into an online setting. This created several challenges, such as providing meaningful learning experiences to engage first- and second-year students, and restructuring course content for the online environment. The objective of our article is to document the transition from on-campus to online teaching and learning, through the consolidation of existing course material and the development of new resources to engage students in an introductory soil science course. We compared on-campus, distance education, and online blended teaching and learning approaches for the same course, and provide lessons learned that may be applicable to other large introductory science courses. Our experience included the use of virtual laboratories, traditional online course materials, synchronous and asynchronous discussions, and the use of question banks for online exams. Recognizing the narrow preparation window, we focused on developing resources that provide benefits beyond COVID-19.

1 | INTRODUCTION

Due to the COVID-19 pandemic we were confronted with the transition of a large, campus-based introductory soil science course into the online setting. This created several challenges such as providing meaningful learning experiences that would engage first- and second-year students in a large virtual-classroom setting (~300 students) and effectively restructuring course content for the online environment. Although we had previously used technology to support our on-campus teaching, the pandemic imposed the need to shift from teaching with technology to teaching through technology (Black, 2020). Online teaching requires planning and intentional course design—developing an uncomplicated course structure, which aligns learning outcomes, assessments, learning activities, and course materials (Harris et al., 2020). Both synchronous and asynchronous learning opportunities need to be considered, along with mechanisms for communication, interaction, and prompt feedback. Synchronous learning is online or distance education that happens in real time, often with a set class schedule, whereas in asynchronous learning, students complete learning tasks on their own because those tasks have not been delivered by an instructor in person or in real time. The choice of technologies to be incorporated should be judicious, content driven, and aligned with learning outcomes (Driscoll et al., 2012; Grant & Thornton, 2007; Harris et al., 2020). With the onset of COVID-19, the speed of the transition to online teaching required that the sequential steps of online course design be collapsed into one stage (Motala & Menon, 2020).

Hodges et al. (2020) draw a clear distinction between well-planned online courses and emergency remote teaching. In the spring of 2020, as universities and colleges around the world went online, we were confronted with the need to rapidly shift from on-campus to online teaching. This presented a unique opportunity to reflect on our teaching practices and to identify areas for improvement. We aimed to document the transition from on-campus to online teaching and learning, through the consolidation of existing course material and the development of new resources to engage students in an introductory soil science course. We compared on-campus, distance education, and online blended teaching and learning approaches for the same course, and provide lessons learned that may be applicable to other large introductory science courses. Our experience included the use of virtual laboratories, traditional online course materials, synchronous and asynchronous discussions, and the use of question banks for online exams. Recognizing the narrow preparation window, we focused on developing resources that provide benefits beyond COVID-19.
world rapidly shifted instruction online in response to the onset of COVID-19, instructors engaged in “online triage” (Gacs et al., 2020), hurriedly prerecording lectures, cancelling labs, inserting online assignments, and developing alternative final exam formats. In planning for the 2020–2021 academic year, the vast majority of the postsecondary instructors were tasked with developing fully online courses. Some postsecondary institutions, such as the University of British Columbia (UBC), Vancouver, Canada, provided substantial support for online course design along with learning management system (LMS) training and multimedia creation, while others offered much more limited support. Even with substantial support provided by the institutions, the time available for restructuring campus-based courses to an online format was too short, especially considering that some instructors needed to develop several courses simultaneously. Generally, planning, preparation, and development of an online course takes between 6 to 9 months (University of British Columbia, 2020; University of Delaware, 2020). The scale of the change and the narrow preparation window, brought by the COVID-19 pandemic, dictated that instructors were still engaged in emergency remote teaching. “a temporary shift of instructional delivery…due to crisis circumstances” (Hodges et al., 2020).

Transitioning to online teaching and learning at universities with a large proportion of international students raises additional challenges including students located in different time zones, prohibited use of specific software apps in certain countries, and limited bandwidth. So, how might instructors leverage existing teaching materials and online resources to shift traditionally taught campus-based courses to the online environment? The objective of our article is to document the transition of a large (∼300 students) science course from a campus-based setting to an online setting, through the incorporation of existing material and development of new resources to engage students. We present an example of a large, introductory soil science course comparing its campus-based, distance education, and online blended versions (Table 1).

2 APPROACHES TO TEACHING AN INTRODUCTORY SOIL SCIENCE COURSE

The Introduction to Soil Science course at UBC is a foundational soil science course for students enrolled in programs in several faculties including Forestry, Land and Food Systems, and Science. The course was initially offered in 1955, and as a service course for several programs it has traditionally had a relatively large enrollment. In addition to the on-campus version of this course, a distance education version, geared toward working professionals, has also been offered at UBC since the 1980s. As a result of the COVID-19 pandemic, the course has been transitioned to a blended online course for the 2020–2021 academic year. Through the example of this introductory soil science course, we provide lessons learned that may be applicable to other large introductory science courses transitioning to the online environment in a limited timeframe.

2.1 Campus-based course

Traditionally, the Introduction to Soil Science course at UBC has been offered on-campus as a lecture-based theory course, which is a typical format for this type of course in Canada. According to a recent survey by Krzic et al. (2018), 93% of introductory soil science courses at Canadian postsecondary institutions are offered as campus-based. Our Introduction to Soil Science course included three, 50-minute lectures per week, over 12 weeks. The course was divided into four units (soil components, soil biology and nutrients, soil classification, and soil management) with associated lecture topics (Figure 1). All course materials, including lecture slides, were posted on the course wiki (https://wiki.ubc.ca/Course: APBI200) at the beginning of the semester to facilitate in-class participation and support students from non-English speaking backgrounds (Babb & Ross, 2009; Macgregor & Folinazzo, 2018).

In addition to campus-based lectures, the Introduction to Soil Science course included laboratory sections that were designed to provide hands-on experiences to reinforce conceptual knowledge from lecture material presented in-class (Matz et al., 2012). Eight labs in total were included, and the laboratory manual was posted on the course wiki (https://wiki.ubc.ca/Course:APBI200). Students were asked to prepare a laboratory report, which typically included data collection, calculations, graphing, and questions related to data interpretation.

During the weeks in which there were no laboratory sections, problem sets were assigned (three in total). Problem sets included calculations, short answer, and quiz style questions (multiple choice, multiple answer), a crossword puzzle designed to reinforce definitions, and worked examples.
| Activity        | Course version | Distance education (pre-COVID-19)                                                                 | Online blended (COVID-19 edition)                                                                 |
|-----------------|----------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| **Course delivery** | Campus-based   | Lectures, on-campus, lecture slides posted in course wiki                                      | Online, text-based course notes posted in LMS                                                    |
|                 |                |                                                                                               | Blended, text-based course notes posted in LMS with synchronous online classes                   |
| **Laboratories** |                | On-campus                                                                                      | Virtual                                                                                          |
|                 |                |                                                                                               | Virtual + synchronous laboratory instruction                                                     |
| **Office hours** |                | Synchronous, on-campus                                                                         | None                                                                                            |
|                 |                |                                                                                               | Synchronous, online                                                                              |
| **Discussion board** | Asynchronous, in course wiki |                                                                                               | Asynchronous, in LMS                                                                             |
|                 |                |                                                                                               | Synchronous, in LMS                                                                              |
| **Readings**    |                | Textbook (supplemental)                                                                         | Textbook (supplemental)                                                                          |
|                 |                | Online readings: SoilWeb200; lecture slides in course wiki                                     | Online readings: course notes in LMS                                                            |
|                 |                |                                                                                               | Online readings: course notes in LMS                                                            |
| **Assignments** |                | Laboratory reports ($n = 6$)                                                                    | Laboratory reports ($n = 7$)                                                                     |
|                 |                | Problem sets ($n = 3$)                                                                           | Problem sets ($n = 3$)                                                                           |
|                 |                |                                                                                               | Weekly assignments ($n = 10$)                                                                     |
| **Midterm exams** |                | Invigilated on-campus                                                                            | Online open-book exam in LMS, time zone accommodation provided                                 |
|                 |                | Sample exams posted in course wiki                                                               | Online, open-book exam in LMS using randomized question banks                                    |
|                 |                |                                                                                               | Online practice exam in LMS                                                                      |
| **Final exam**  |                | Invigilated on-campus                                                                           | Invigilated on-campus (option to write off-campus at an approved facility)                     |
|                 |                |                                                                                               | Online, open-book exam in LMS using randomized question banks, time zone accommodation provided |
|                 |                |                                                                                               | Online practice exam in LMS                                                                      |

*Note.* LMS, learning management system; course wiki, [https://wiki.ubc.ca/Course:APBI200](https://wiki.ubc.ca/Course:APBI200); SoilWeb200, [http://soilweb200.landfood.ubc.ca](http://soilweb200.landfood.ubc.ca); invigilated, students are watched during an exam to check that they do not cheat.
Both synchronous and asynchronous student support were provided through office hours and an online discussion forum. Drop-in, office hours were held on-campus by both instructors and teaching assistants, totaling 10 hours per week. The discussion forum on the course wiki offered an asynchronous learning alternative for students. By providing both synchronous and asynchronous options for students to ask questions, we aimed to meet the needs of diverse learners present in this course (Johnson, 2006).

Course readings were comprised of a recommended textbook and supplemental online material posted on the SoilWeb200 website (http://soilweb200.landfood.ubc.ca). The recommended textbook for the course was the Elements of the Nature and Properties of Soils by Brady and Weil (2010).

Assessment of student learning was based on laboratory reports (25% of final grade), problem sets (10%), two midterm exams (25%), and a final exam (40%). The weighting on the final exam reflected the cumulative nature of the course material and was substantive enough to allow for grade improvement (Franke, 2018). Practice exam (or review) sessions were held prior to the exams by dividing students into breakout groups of six to eight students. Each group was randomly assigned one question from a set of six and given 15–20 minutes to develop an answer. This peer-to-peer exercise reinforced key concepts through retrieval practice.

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**FIGURE 1** Graphic syllabus showing four course units and associated lecture topics for the on-campus Introduction to Soil Science course offered at the University of British Columbia, Vancouver, BC, Canada.

| SOIL COMPONENTS | SOIL BIOLOGY & NUTRIENTS |
|-----------------|--------------------------|
| ▸ Soil solids   | ▸ Soil organisms         |
| □ Mineral particles (sand, silt, clay), their size & composition |
| □ Soil organic matter |
| ▸ Soil water    | ▸ Biochemical transformations carried out by organisms: |
| ▸ Soil air      | □ Biological N fixation  |
| □ Important properties of soil components | □ Mineralization & immobilization |
| □ Soil texture  | □ Denitrification         |
| □ Bulk density & particle density | □ Interactions of soil microbes with plant roots (rhizosphere and mycorrhizae) |
| □ Porosity, pore size distribution, and aggregation (i.e. soil structure) |
| □ Presence of charge on soil particles & ion adsorption |
| □ Water retention |
| □ Thermal properties |
| □ Soil reaction |
| □ Salinity |

| SOIL CLASSIFICATION | SOIL MANAGEMENT |
|---------------------|-----------------|
| ▸ Soil formation & weathering | ▸ Urban soils |
| □ Five factors of soil formation |
| □ Soil formation processes (additions, translocations, transformations, losses) |
| ▸ Soil horizons & forest floor | ▸ Soil degradation |
| □ Canadian system of soil classification & 10 soil orders: | □ Soil erosion and its control |
| □ Regosol |
| □ Brunisol |
| □ Luvisol |
| □ Gleysol |
| □ Organic soil |
| □ Chernozem |
| □ Solonetz |
| □ Podzol |
| □ Cryosol |
| □ Vertisol |
| □ Soil quality |
| □ Soil ecosystem services |
between peers and allowed students to gain experience integrating and interpreting information (Karpicke & Blunt, 2011; Stigmar, 2016). Sample exams were posted on the course wiki, and questions in laboratory reports and problem sets mimicked the format of quiz, calculation, and short answer questions on the exams. In this manner we aimed to familiarize students with the style of questions they would see on the exams, and reward students for participating in the practice exam session and reviewing previous exam questions (Hochstein & Lake, 2019).

### 2.2 Distance education course (pre-COVID-19)

A distance education version of the Introduction to Soil Science course has been offered at UBC through continuing studies during the summer semester. The distance education version was geared largely toward working professionals, many of whom require a soil science course for their professional designation (e.g., professional agrologist, professional forester). With the emergence of information technology, the distance education version of the Introduction to Soil Science course went through major revisions in the early 2000s that included the restructuring of laboratory sessions, the development of virtual labs, and moving the course material into a LMS. Core course content was largely text-based and supplemented with images, graphics, and short videos. The text-based content parallels the lecture material taught in the on-campus version of the course, covering seven modules over 12 weeks. Students had flexibility regarding when they review course materials, but the assignments had set due dates. Supplemental readings provided for this course version were similar to the on-campus version, using the same recommended textbook (Brady & Weil, 2010), and SoilWeb200 (http://soilweb200.landfood.ubc.ca).

For the distance education version, no office hours were scheduled, and the discussion forum in the LMS was used to respond to student questions. Although we recognize the benefits of using both synchronous and asynchronous discussions within a course (Johnson, 2006), asynchronous communication between students and the instructor was purposefully selected to support students and professionals working over the summer semester, and to facilitate interactions among students from different time zones.

There were six virtual laboratory sessions associated with the distance education course designed to support students’ conceptual understanding (Rowe et al., 2018). The online laboratory manual included: background information on the field or laboratory procedures, short video clips demonstrating the method(s), sample data, and analysis tips. Laboratory assignments contained data, instructions for calculations and data presentation (e.g., graphing), and conceptual questions relevant for the specific lab. In the final laboratory of the course, students were asked to dig a soil pit, complete a data collection form for their soil pit, and write a short synthesis of their field observations referring to the factors and processes of soil formation at their site.

Assessment for the distance education course was similar to the campus-based version of this course, incorporating laboratory assignments (n = 6), problem sets (n = 3), and an invigilated final exam; in addition, graded practice exams and online quizzes (n = 2) were used. Practice exam questions were posted as a low-stake group assignment, facilitating students to learn from each other (Duret et al., 2018). Students developed an infographic for their assigned question, and sample infographics selected by the instructor were subsequently posted to the discussion forum for peer-review. Quizzes were 50 minutes in length but could be taken by students anytime over a 2-day period, and question banks were used to randomize questions among students. In this manner, we were able to accommodate work schedules and time zones while minimizing academic misconduct (Santos et al., 2019). As the final exam was invigilated, and not all students were located in the Greater Vancouver region, students could apply to write their final exam at a partner exam center.

### 2.3 Online blended learning (COVID-19 edition)

Planning and development of the online blended version of this introductory level course was based on our experiences offering the campus-based and distance education versions, and the rapid online transition that occurred in March–May of 2020 when all courses at UBC were moved online. Spring 2020 gave us a preliminary sense of online teaching and learning, but at the time our university shut down (13 Mar. 2020), we had already built strong relationships with students in our classroom, and we were able to interact virtually, and largely asynchronously to complete the semester. Starting with a new group of mainly first-year students (n = 300), our online course that commenced in January 2021 is offered as a flipped classroom. It blends asynchronous learning focused on the text-based content and virtual laboratories with synchronous online classes and office hours.

The text-based content in the LMS for the distance education version of the Introduction to Soil Science course was in a modular format (Mendez-Carbajo & Wolla, 2019), but has been further revised for equivalency with the campus-based version and restructured into weekly modules (n = 12). Each module includes content material for that particular week, supplemental readings, and an assignment (Figure 2). The text-based content was revised, eliminating any information that went beyond the introductory level. The aim of the revision was to reduce cognitive load and adhere to the
coherence effect, which is in agreement with findings of Mayer et al. (2001) that interesting but conceptually extraneous details can have negative effects on students’ learning. To complement the asynchronous text-based content, weekly synchronous (live) classes of 50 minutes have been scheduled on Fridays (Figure 2). Prior to those synchronous classes, students are asked to review the online content. During the weekly synchronous class, the instructor reviews core content and uses in-class anonymous polling to focus on challenging concepts, so called “muddiest points” (Carberry et al., 2013). Through the combination of synchronous and asynchronous sessions, we aim to enhance teaching presence, optimize student time on course material, accommodate students in different time zones, and maximize student learning in the online environment (Guo, 2020; Marshall & Kostka, 2020).

Virtual laboratories, similar to the distance education format are offered, but the laboratory manual in the distance education course has been dismantled and relevant sections added as virtual labs to specific weeks. Videos heavily focused on laboratory procedures have been removed and replaced by newly created videos that focus on concepts and data interpretation. Given the challenges of students accessing outdoor sites to dig a soil pit, the self-guided field observation lab used in the distance education version is not included. Instead, forest floor and parent material labs, used in the campus-based version of this course, have been added. Both of these “new” virtual laboratories draw heavily from existing online resources: the Forest Floor (https://forestfloor.soilweb.ca) and Soil Formation and Parent Material (https://landscape.soilweb.ca) websites developed by the Canadian Virtual Soil Science Learning Resources group (https://soilweb.ca). Similar to the campus-based version of this course, each of the 10 synchronous laboratory sections (with about 30 students) are led by an instructor or teaching assistant. Weekly teaching team meetings are led by the course instructors, and teaching assistants are provided with lessons plans and detailed marking notes for each week. During the synchronous laboratory sessions, students work collaboratively in breakout groups on an activity focused on that week’s laboratory topic, and key soil science concepts are clarified in plenary. These synchronous laboratory sessions also provide opportunities to have students’ questions answered, thereby also serving as synchronous office hours.

In addition to synchronous class and laboratory/office hours, instructors monitor an asynchronous discussion forum in the LMS. Students can post questions and answer questions of their colleagues; instructors monitor and respond daily. The anytime–anywhere format of the asynchronous discussion has been successfully used in our on-campus course since 2013. Our experience is 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 (Li et al., 2010; Johnson, 2006).

Supplemental to the text-based content in the LMS, we use the same textbook (Brady & Weil, 2010) as in 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). For the COVID-19 edition of our course, the textbook remained as recommended, and we have indicated specific page numbers from the textbook within the weekly modules. As of 2021–2022 academic year, we hope to use the Canadian-based, open access textbook for introduction to soil science courses as the recommended textbook. This textbook is currently being developed by more than 40 members of the Canadian Society of Soil Science, and will be produced as an open educational resource (OER) available to instructors or students without cost, and with an open license allowing for reuse, revision, and redistribution.

Student assessment continues to be based on assignments, and midterm and final exams; however, lab assignments and problem sets from the campus-based version of this course have been amalgamated as weekly assignments, and only one midterm (as opposed to two) is given in the online course. Assignments are posted on the LMS; students upload their assignments, and teaching assistants, under the supervision of instructors, provide written feedback through a rubric incorporated in the online grading system. These assignments mimic the style of questions students will see on their online exams (e.g., compare and contrast questions, multiple answer questions). An honesty pledge is added to each assignment, where students affirm that “all answers are written in their own words.”

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

*Synchronous lab / office hour times vary by lab section. Your individual lab / office hour time may be on Monday, Tuesday, Wednesday, or Thurs.

FIGURE 2 Example of a weekly student schedule showing synchronous (live) and asynchronous activities in the online blended learning version of the Introduction to Soil Science course offered at the University of British Columbia, Vancouver, BC, Canada.
In line with the analysis of Dadashzadeh (2020), the weighting of course components has been shifted slightly, giving more points to assignments (60%) and reducing the weight on the midterm (15%) and final exams (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 are a mix of short answer and quiz style questions, to be drawn randomly from a series of question banks, and are time limited. Exams are similar to the campus-based version in both question style and length, but comprehensive question banks have been developed. Exam questions are randomly selected using the quiz settings within the LMS so that each student receives a different combination of questions on their exam. The honesty pledge attached to the assignments is included at the beginning of the exam. A practice exam is posted in the LMS that uses the same format and number of questions, allowing students to become familiar with the online editor and the timing of the exam. This approach is in line with research that has shown formative assessments (such as practice exams) lead to enhanced learning and retention (Roediger & Karpicke, 2006). Time zone accommodation is provided to students based on academic hardship recommendations from the University’s Centre for Accessibility.

3 | BEYOND COVID-19: INCORPORATING CHANGE FOR FUTURE LARGE COURSES

Strategies for moving classes online are influenced by an instructor’s familiarity with online learning, whether laboratory content is included, the age and experience of students, class size, the availability of existing online materials that may be adapted, and the time available for planning and reorganization (Bailey & Lee, 2020; Procko et al., 2020). The narrow preparation window for moving courses fully online during the COVID-19 pandemic requires judicious change. Taking a backward design approach (Wiggins & McTighe, 2005), starting with learning outcomes, remains beneficial in prioritizing content and aligning assessments with learning outcomes in the online environment. However, the available time is too short for complete course redesign (Gacs et al., 2020). Our approach, and one we recommend, has been to draw from existing online resources and develop a limited number of new resources that will enhance our course(s) post-COVID-19. From the process of redeveloping our Introduction to Soil Science course for an online setting, we can offer several suggestions for others facing this similar challenge.

3.1 | Week-by-week course structure

We opted to develop a week-by-week course structure, grouping content by weeks instead of blocking them into thematic modules (Major et al., 2018). The existing online course notes were streamlined, and extraneous material was removed to facilitate learning (Mayer, 2017). Select material from external sources (e.g., SoilWeb200, https://soilweb.ca) was integrated directly into the online course notes, so that all material was contained within the LMS. The resulting online course notes support the current COVID-19 course edition, as well as provide our future campus-based classes with comprehensive notes to complement campus-based lectures.

3.2 | Redesigning assignments

Laboratory assignments and problem sets from the campus-based version were merged and redeveloped into assignments that are aligned with weekly topics in the blended online version of the course. The focus of the laboratories shifted from procedural (hands-on) to interpretation and understanding key concepts (Faulconer & Gruss, 2020). A few new videos were created and are a required viewing before the synchronous labs. For example, a video has been developed using several soil monoliths from the UBC’s collection (https://monoliths.soilweb.ca) to explain diagnostic horizons, a concept that proved to be a “muddy point” for students during the rapid online transition in the spring of 2020. The resulting collection of short videos, focused on learning outcomes, supports weekly assignments in the COVID-19 edition of the course, and will be incorporated as part of on-campus laboratories post-pandemic.

3.3 | Building comprehensive online question banks

Quizzes within an online LMS offer a range of question formats including multiple choice, multiple answer, matching questions, essays, and numeric responses. In addition, quizzes may be time limited, questions randomized, students given multiple attempts, and adjustments made to accommodate individual student concessions (granted by our university’s Centre for Accessibility). Through university funding available to support the transition to online teaching, we hired a part-time teaching assistant to compile and organize quiz questions. Question banks were created for major themes (i.e., soil physics, soil chemistry, soil biology, soil
classification, etc.) and question types (e.g., short answer, data interpretation, multiple choice), which facilitates the creation of exams with a preset number of questions randomly drawn from specific question pools. In this way, individual students receive different but equivalent exams. Additionally, multiple choice, multiple answer, and matching questions are self-grading in the LMS used by UBC, which is advantageous in a large class. During the COVID-19 pandemic, we have chosen not to proctor online exams, but to have open-book exams using randomized questions drawn from question banks and to time constrain tests (Dadashzadeh, 2020). After COVID-19, for this large, introductory, required science course we will return to invigilated exams, but the question banks will enable multiple iterations of practice exams to support learning through retrieval practice (Karpicke & Blunt, 2011).

3.4 Blending synchronous and asynchronous instruction

The international nature of our university—with students in different time zones—and concerns for sustainable student workloads led to our decision to blend synchronous and asynchronous course delivery. Students review online course content asynchronously, and we hold synchronous classes once per week. A mix of synchronous and asynchronous instruction has been shown to enhance student performance in general and during the COVID-19 transition (e.g., Guo, 2020; Watts, 2016; Johnson, 2006). Additionally, we leverage our teaching assistants to support online learning (Talbot & Huvard, 2020) through 2-hour synchronous “laboratory sections” (Figure 2). The campus-based version of the Introduction to Soil Science course, in the past, was largely synchronous, and it is our intent post COVID-19 to return to a largely synchronous format. However, asynchronous discussions and online course materials (for both lecture and laboratories) will be retained.

3.5 Student engagement

The transition to online teaching and learning has compelled us to reflect on strategies to enhance student engagement in a predominantly lecture-based course. Our approach has been multi-faceted: using questioning as an instructional method in synchronous classes (Campbell & Mayer, 2009); incorporating collaborative group work within synchronous laboratory sessions (Martin & Bolliger, 2018); and providing an asynchronous discussion forum (Li et al., 2010). By providing multiple opportunities for students to interact with content, instructors, and peers, we seek to provide engaging learning experiences and build a sense of community in the online environment. Although online and face-to-face activities may lead to similar levels of academic performance, research suggests greater student engagement in face-to-face activities (Kemp & Grieve, 2014) and supports blending of face-to-face and online learning post-pandemic.

4 CONCLUDING REMARKS

The COVID-19 pandemic has necessitated online teaching approaches for instruction originally designed for in-person delivery. The timeframe for preparation has been insufficient to undertake comprehensive course redesign, but opportunities exist to leverage existing online content, incorporate synchronous and asynchronous elements into courses, and build value-added online resources that will have utility beyond the COVID-19 pandemic. For a large introductory science course, a clear structure (such as weekly) that aligns content and assessment with learning outcomes is, in our opinion, fundamental and a critical first step in transitioning to online teaching and learning. Pre-existing course materials, including videos, laboratory manuals, and assignments, may require revision to align with learning objectives. A combination of synchronous and asynchronous classes, office hours, and virtual laboratories are encouraged to accommodate students’ schedules and to enhance student engagement. Recognizing the narrow preparation window, judicious change focused on developing resources that provide benefits beyond COVID-19 are endorsed.

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AUTHOR CONTRIBUTIONS

Sandra Brown: Conceptualization; Writing-original draft; Writing-review & editing. Maja Krzic: Conceptualization; Writing-original draft; Writing-review & editing.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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