Transitioning an Experiential Education Unit in Veterinary Medicine to Hybrid and Online Learning Environments

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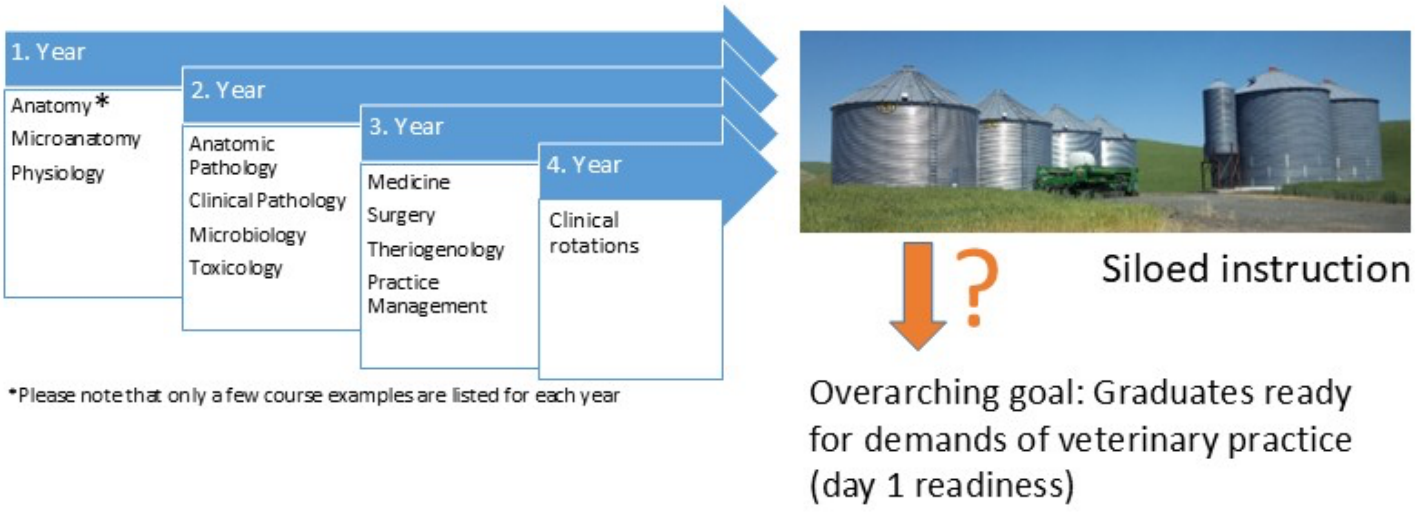
Abstract

This paper describes the transition of a skills-based Histopathology Elective course in the veterinary curriculum at Oregon State University from in-person to hybrid and fully online formats. The course redesign was prompted by both pedagogical goals and logistical constraints and was accelerated by the COVID-19 pandemic. Using a case-based, experiential learning framework, the course integrated whole slide imaging (WSI) technology to supplement or replace traditional glass slides and microscopes. The paper outlines a study that was designed to explore student and instructor experiences across delivery modalities, focusing on engagement, learning outcomes, instructional workload, and the use of digital tools. Observations suggest that hybrid and online formats of the course offered increased flexibility, accessibility, and additional opportunities for self-paced learning, while also supporting reflective clinical reasoning, teamwork, and communication. Limitations included challenges in facilitating group discussions, reduced immediacy of feedback, and diminished access to tactile learning experiences. The observations underscore the importance of intentional instructional design and highlight the potential of hybrid models to balance increased accessibility and technological innovation with the pedagogical value of hands-on learning.

Curricular context

The transition from theory to application is a critical aspect in the veterinary curriculum as students near entry into the veterinary profession. The traditional veterinary curriculum involves building a strong foundation in basic sciences such as anatomy, physiology, and pharmacology, followed by the study of disease mechanisms and clinical sciences (Figure 1). If the content at each level is organized by organ systems, the resulting learning spiral supports the recurring exploration of related topics in an iterative process. The process ultimately culminates in the practical application of theoretical knowledge and practical skills during clinical rotations in the final year(s) of veterinary school (Figure 1). However, students often struggle with the integration and application of large amounts of theoretical information into the clinical context and specific cases, leading to apprehension and anxiety surrounding the transition from the classroom and on to the clinic floor.

Figure 1. High level overview of the current veterinary curriculum at the Gary R. Carlson, MD, College of Veterinary Medicine.



Educational frameworks

Learning has been defined by Kolb (1984) as "the process whereby knowledge is created through the transformation of experience" (pg. 38). Experiences in and of themselves do not generate effective learning opportunities. For experiential education (instructor driven) to translate into experiential learning (learner centered), experiences have to be juxtaposed to cognitive integration such as reflection, application, and extrapolation. That is, "experiential learning requires structure to help students make meaning from experience" (Hommel, 2019, pg. 2), ideally following the four stages of the adaptive learning modes as designed by Kolb (1984). Hommel (2019) interprets the 4-stage experiential learning cycle by Kolb (1984) as follows: "...Concrete Experience/Abstract Conceptualization represent[s] opportunities for interpreting experience. Reflective Observation/Active Experimentation represent[s] two different and opposed ways of transforming the grasping of experience into new knowledge" (Hommel, 2019, pg. 3).

Interactive learning is essential for engaging adult learners and making the learning experience more realistic and creative. A framework that combines experiential with interactive learning is the Case Method or its refined model of Case-based collaborative learning (CBCL), an instructional approach that uses real-world or simulated scenarios presented to a team of learners to foster critical thinking and collaborative problem-solving among others (Besche et al., 2022). Rooted in constructivist theory, CBCL encourages students to apply theoretical knowledge to practical situations, enhancing their analytical and decision-making skills. This learner-centered method promotes deeper understanding by engaging students in discussion, reflection, and inquiry, often in interdisciplinary contexts. Designed for use in medical education, CBCL supports the development of transferable skills essential for professional practice and lifelong learning.

Course structure, affordances, and limitations

Course goals

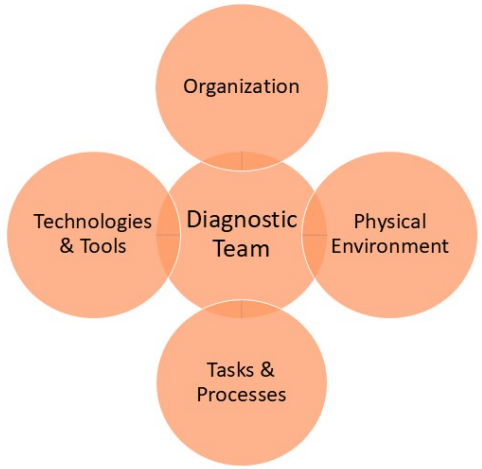
The Histopathology Elective course in the Veterinary Curriculum of the Gary R. Carlson, MD, College of Veterinary Medicine (CCVM) is designed to support students in the transition from more traditional transmissive learning to the more social, conversational, and constructive learning in a clinic setting. The course provides an interdisciplinary approach and is centered on practice-relevant content. The overarching goals of the course are to foster vertical integration of foundational knowledge and skills in microanatomy, physiology, pathology, medicine, surgery, and oncology; provide students with an opportunity to explore the utility and limitations of common diagnostic approaches used in companion animal practice; and develop an understanding of best practices in the diagnostic work-up of common disease conditions. The course provides a simulated environment of the veterinary practitioner in which it is safe to explore, make mistakes, and fill in gaps without affecting patient care (Figure 2).

Course description

The course utilizes situational simulations and real-life cases sourced from the Oregon Veterinary Diagnostic Laboratory (OVDL) to illustrate the logical progression in the work-up of clinical cases. Each case starts with the patient history and clinical presentation provided by the submitting veterinarian, the process of analyzing cytology and histopathology slides and interpreting findings to formulate morphologic and clinical diagnoses, and culminates in the communication of results in conversation and writing to clients and patient owners. The course runs as one-week sessions in the spring quarter of year 3 of the 4-year veterinary curriculum, parallel to the introduction of students to the mechanics of the veterinary teaching hospital and patient care (Figure 3).

Figure 2. The clinical diagnostic team operates in a broader organizational context including the physical environment, activities, infrastructure, and tools (A) and draws from the expertise of other disciplines such as pathology (B). These complex contexts and interactions in the work-up of clinical patients have to be considered when constructing simulations and virtual cases. Graphics adapted from: Improving Diagnostic Health Care (2015). The National Academies Press, pg. 35 & 152.

A



Adapted from: **Improving Diagnosis in Health Care (2015),** p53, The National Academies Press

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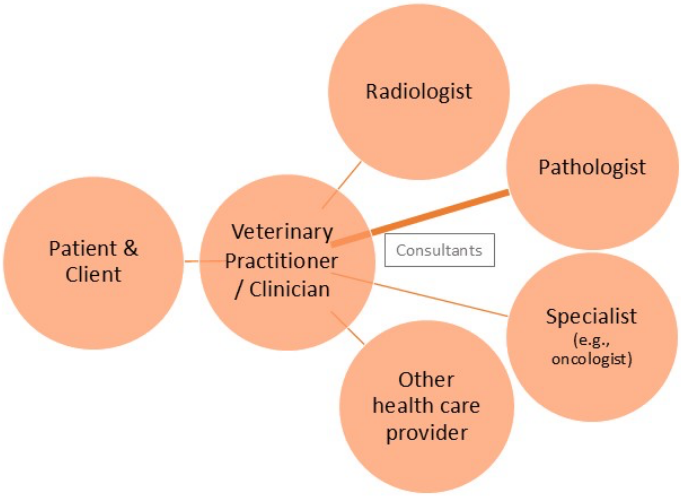
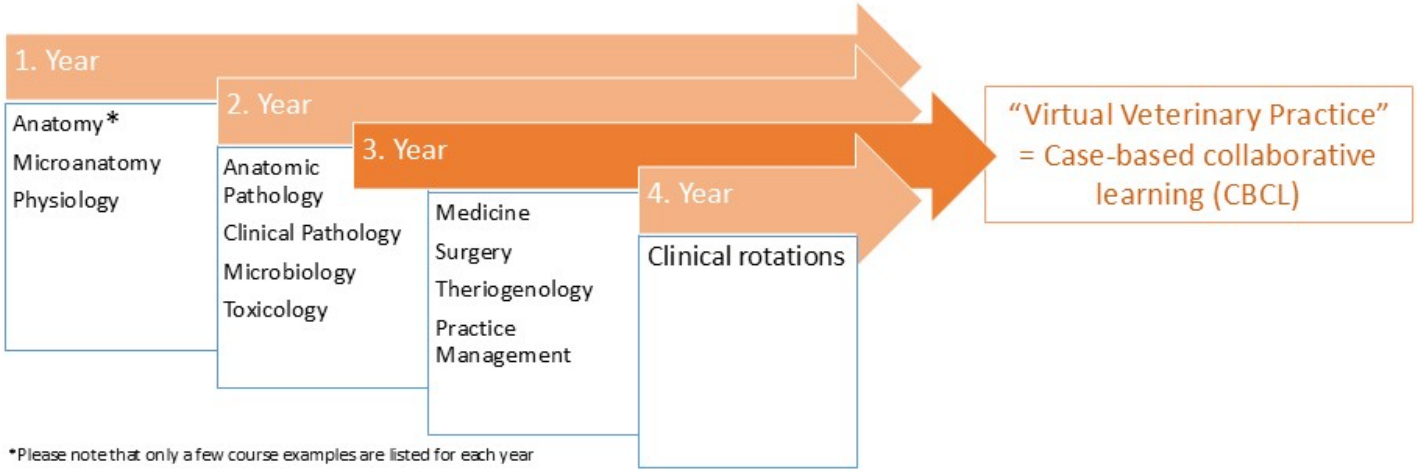


Adapted from: **Improving Diagnosis in Health Care (2015),** p152,The National Academies Press

Figure 3. Placement of the Histopathology elective course in the context of the current veterinary curriculum at the Gary R. Carlson, MD, College of Veterinary Medicine.



In order to incorporate communication and social dimensions, the course uses independent study, teamwork, group discussions, writing, and reflection.

Course limitations

The course was originally designed for in-person delivery using a student teaching laboratory with dual-headed microscopes for independent and small group work and a 10-headed microscope for large group discussions. Initially, the course was limited to 9 students per session. The acquisition

of a high-resolution video camera and overhead monitor allowed an increase of the session size to 12 students but was still limited by room size and availability of teaching materials, especially cytology slides (often a single glass slide; Figure 4). Applicant numbers routinely outnumbered available seats, clearly communicating student interest in the course.

Figure 4. Images illustrating the analog (hardware) components of the in-person Histopathology Elective course. Clockwise from top left: medical records, box with glass slides, laboratory space used for independent study, dual-headed microscope used by small groups, 10-headed microscope with video camera and screen for group discussions, and glass slides (top: histology, bottom: cytology).

Overcoming course limitations – Course redesign for hybrid delivery

The Appendix A table titled "Current approaches to the delivery of instruction – definitions and theoretical grounding" provides a brief synopsis of terms used to describe current formats of instruction including in-person, face-to-face, online, remote, hybrid, and mixed-modality modes of instruction. Hybrid courses are a structured blend of in-person and online components that are intentionally integrated to support learning outcomes. The hybrid course delivery model is

based in blended learning theory and constructivist approaches and supports flipped classrooms and differentiated instruction (Johnson et al., 2022).

Recent advances in technology and microscopy now allow for the scanning of microscopic glass slides and generation of digital whole slide images (WSI). Slide scanners with a range of capabilities have become widely available and more affordable.

The size of generated WSI ranges from 0.5 GB to 5 GB and transfer limitations from the physical infrastructure to the data infrastructure, chiefly file hosting, access, sharing and viewing. Nonetheless, these technological advances provided the opportunity to adapt the Histopathology Elective course to a hybrid format with the primary goal to accommodate a larger number of students, provide broader accessibility, and reduce pressure on limited resources. However, the changes in content delivery also raised questions about the potential effects on students' interest, engagement, and learning (Schrum, 2000). Furthermore, the incorporation of new or different technology in and of itself does not automatically result in better instruction and needs careful consideration and deliberate implementation (Chickering & Ehrmann, 1996). These questions formed the basis for a research project funded and supported by the OSU Ecampus Research Fellows Program. The primary goal of the originally designed research study was to examine what if any impacts a hybrid delivery of the course with use of WSI instead of glass slides would have on course dynamics, student perception, and learning outcomes.

Study purpose and research questions

The goal of the originally designed study was twofold; firstly, to document student perceptions of an experiential learning unit in the veterinary curriculum comparing a hybrid delivery format incorporating the use of WSI to the traditional face-to-face delivery format using glass slides and microscopes. Secondary goals were the documentation of: any effects the course delivery format may have on learning outcomes; students' time commitment and specific activities during independent study times; student learning both subjective (their own perception) and objective (performance on a low-stakes take home quizzes); and instructor perception of student participation, engagement, and time commitment.

The original research questions were as follows:

RQ1: What are students' perceptions of in-person vs hybrid delivery of an experiential learning unit in the veterinary curriculum?
RQ2: What are students' perceptions and acceptance of the use of WSI compared to glass slides?

RQ3: Does the delivery method (in-person vs hybrid) and the use of the slide format impact student learning and students' perception of their own learning?

RQ4: What challenges surfaced in the deliberate and guided preparation of a course for the transition from in-person to hybrid delivery?

Module design

The Histopathology Elective course is a 1-week, 20-hour course delivered in two consecutive, repeating sessions in the spring quarter. OSU uses Canvas® as the official online course management system.

In Canvas, the course begins with an introductory module explaining the goals of the elective, schedule, and expectations to be met for successful completion. It also introduces students to the course mechanics such as the location of materials, case reports and worksheets, and the use of the discussion forum and submission portal for their work. Students are also expected to complete a document both pre-elective and post-elective to foster reflection on their own knowledge, perception of their knowledge, learning, and goals for the elective.

The course content is organized into four modules that focus on themes relevant to practicing veterinarians. Each module is based on multiple cases sourced from submissions to the OVDL. Cases are used to illustrate the process of working up clinical cases in the collaboration of practicing veterinarians and diagnosticians, usually in geographically disparate locations. The inclusion of multiple cases in each module allows for the comparing and contrasting of specifics of the

disease entity, quality of the submission, correlation between cytology and histology, utility of additional diagnostic tests, and interpretation of results in the clinical context.

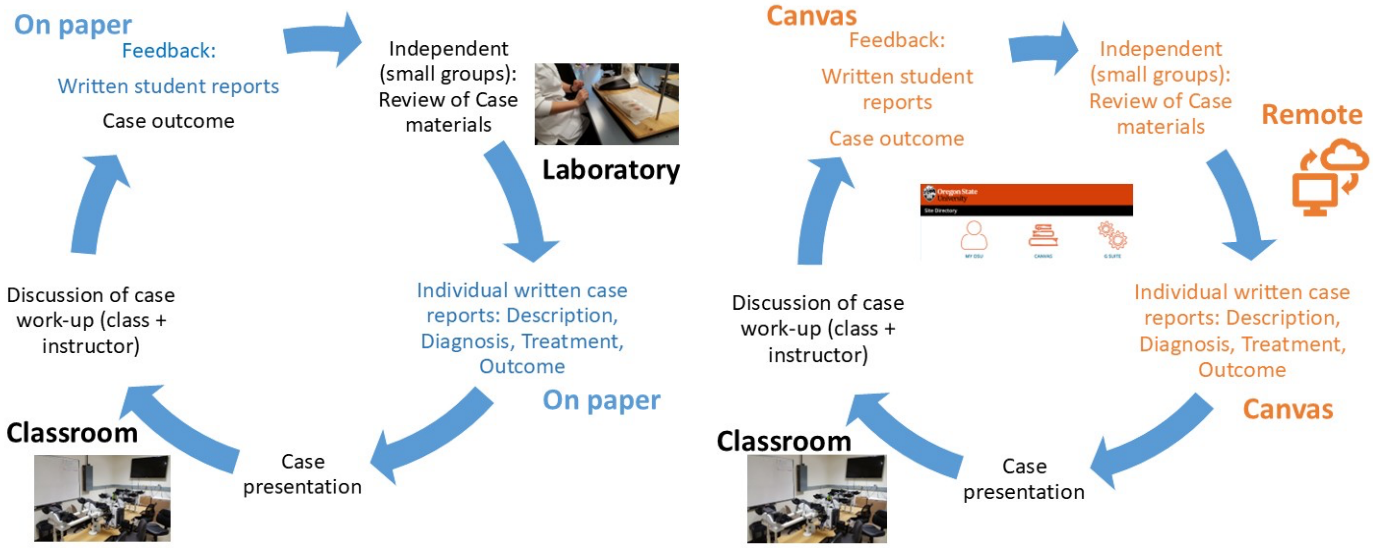
Each module is presented in the same basic format: 1) An introduction page with the goals for the module is followed by a page providing the location of relevant documents (information about cases, worksheet for the module, case report template with prompts, and associated materials); 2) followed by a page with links to the submission portal and discussion forum (required posting); and 3) a page of the findings associated with specific cases in the context of the session goals.

For each case the following materials are provided in Canvas: patient history, original submission form sent in by practicing veterinarian, clinical history (when available), in some cases additional clinical or laboratory data (CBC, chemistry, urinalysis). A hard copy of each day's worksheet and the submission forms are also provided with the glass slide sets. Figure 5, illustrates the flow of each module. During self-study time, students work through all cases and provided materials alone or in small groups, mostly dyads. This is followed by the discussion session around the multiheaded microscope with the capability to project fields of view to an overhead TV screen or online forum and a whiteboard to share ideas and explain concepts.

Hybrid delivery

Digitized glass slides can be viewed with image or photo software or dedicated imaging freeware/ imaging software. To prepare the course for hybrid delivery, the Canvas course site was modified, and a new course syllabus was written to include instructions for both delivery formats to lower potential barriers associated with independent learning delivered through an online platform. The image files were accompanied by a word document with live links to file locations to facilitate access and ensure the correct images were linked to each respective case. The course mechanics essentially stayed the same (Figure 5).

Figure 5. Diagrams illustrating the flow of instructional activities of the Histopathology Elective course delivered in-person (left) and in the hybrid format (right). In person activities and interactions are in black, written documentation on paper in blue, online or remote activities in orange.

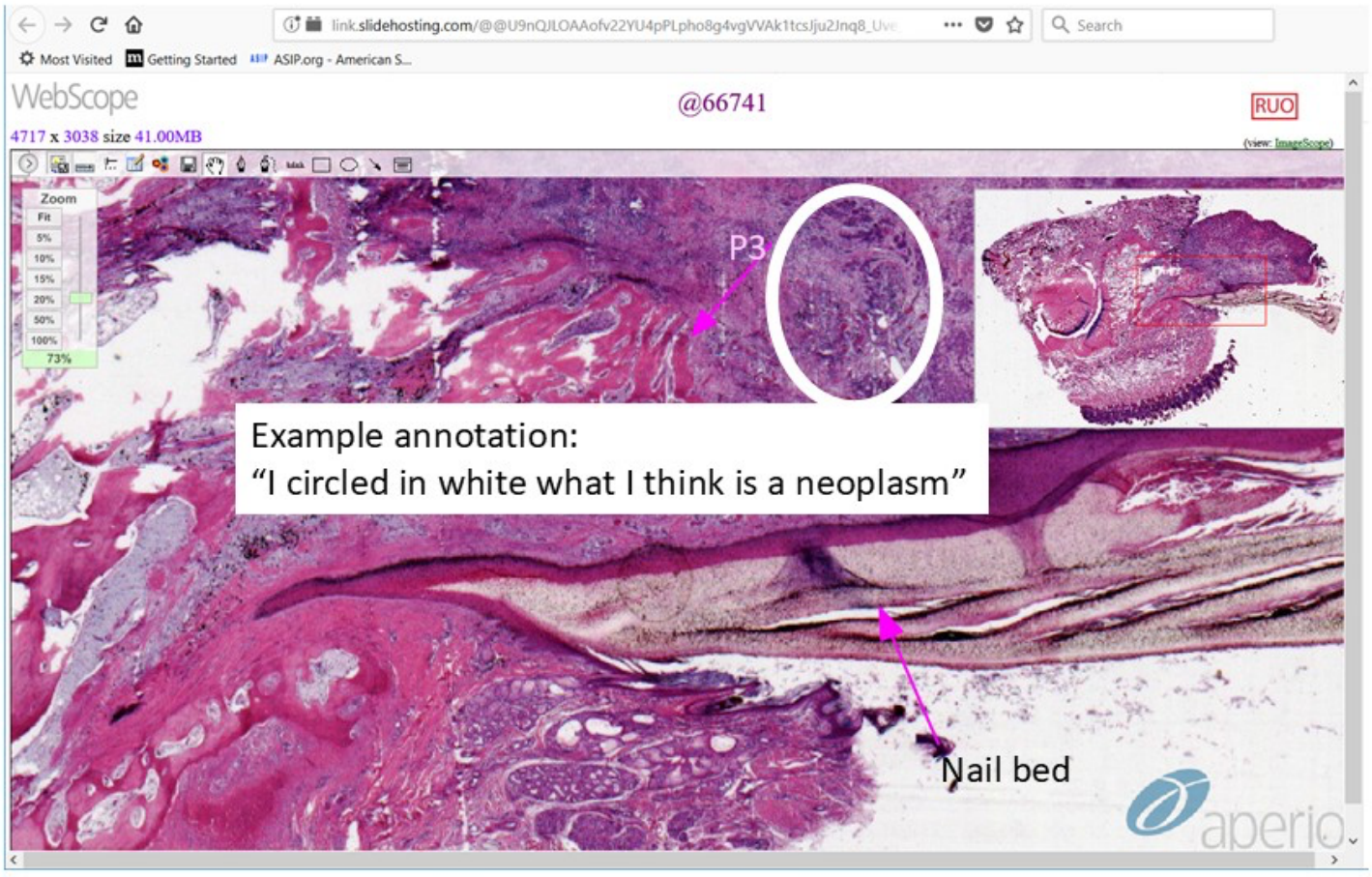


Hardware and software

Cytology slides were originals submitted by practicing veterinarians to the OVDL that were either Diff-Quick or Wrights-Giemsa stained. Recuts of histology slides were generated and stained with hematoxylin and eosin; in some cases, specially stained by histochemistry or immune-histochemistry to highlight specific structures. During in-person self-study, dual-headed microscopes (Leitz Laborlux S Dual) and glass slides were used. Students had access to the laboratory, microscopes and slides for four hours during the scheduled class time and afterhours (5pm to 8am). During large group discussions, glass slides were viewed using a Nikon Eclipse 80i microscope with 10 heads and the field of view projected to an overhead TV screen using Nikon BR® image software and live video camera.

Whole slide images (WSI) were generated as low resolution overview (4x) using SciScan® and areas of interest at 20x or 40x using a Leica DM4 B. Some companies now provide virtual slide boxes that support viewing of images in a browser window, basic annotation tools, and links to additional case material (example shown in Figure 6). However, these platforms generally come with a license fee, so we chose a low-cost option. Image files were uploaded to a secure online storage system (Box®) and access was provided through direct invitation and linking out from the Canvas course site. Image files were also provided on portable flash drives if students preferred direct file transfer over transfer via internet access.

Figure 6. Screenshot of the virtual slide box (hosted by the Leica Education system; no longer available) shows the overall layout and an overview of a whole slide image (WSI, top right), the magnified area (main window), labels (P3, Nail bed; provided by the instructor) and an example annotation by a student.



Study preparation and participant recruitment

The study was approved by the Institutional Review Board (IRB) at OSU. The principal investigator, a faculty member in the Department of Biomedical Sciences at the CCVM at OSU, designed and delivered all sessions of the course. A clinical fellow in the Department of Biomedical Sciences and a faculty member of the Ecampus Research Unit served as study coordinators. Study participants were recruited from classes in the third year of the veterinary curriculum at OSU from 2020 through 2024. Included here are observations gathered 2019 through 2023 and preliminary results from data collected in 2021, 2022, and 2023. Only students enrolled in the Histopathology Elective course were eligible to participate. All participants read and acknowledged an informed consent, which was provided both in paper and electronic format. The consent process was conducted verbally in-person (paper form) or remotely (electronic form) depending on the year and/or preference of the participant.

Enrolled participants were given the choice of taking the course face-to-face or in the hybrid format. Announcements were sent by email and posted as flyers in common use areas. Study participants were offered a small financial incentive (up to $80) to encourage enrollment and collection of additional data associated with the study. The incentive was staggered to provide a partial reward for partial completion.

Study context and adaptation to pandemic conditions

This study was originally designed to evaluate the impact of instructional delivery formats - specifically in-person compared to hybrid - on student learning outcomes and perceptions in a professional health sciences unit. However, the emergence of the SARS-CoV-2 (COVID-19) pandemic in March 2020 necessitated a rapid institutional shift at OSU from in-person to (emergency) remote instruction. This transition began with final examinations in the winter quarter and continued into the summer term.

With two weeks' notice, the course was adapted from hybrid to fully online delivery (2020), largely by addressing face-to-face elements: replacing in-person with synchronous online instruction. An amendment to the study protocol was submitted to the IRB to reflect this change. Consequently, data collection for the research study was delayed and commenced in spring 2021.

Instructional modalities across study years

In the first year of the study (2021), the course was largely delivered remotely with limited access to the on-campus laboratory space intended as independent study space and the multiheaded microscope designed for group discussions (6 ft distancing; predefined, limited number of people per room). This approach aligned with OSU's public health guidance in compliance with guidance by the state of Oregon.

In the second year of the study (2022), the course was offered in three modalities: fully online, as hybrid, and in-person. This approach best aligned with OSU's emphasis on returning to in-person instruction as part of a broader institutional effort to re-engage students in classroom-based learning and OSU's public health guidance. It was also intended to accommodate students' varying health concerns and personal preferences. All students who completed the additional tasks associated with data collection received a financial incentive, regardless of the delivery format they selected.

In the third year (2023), the course was delivered in all 3 modalities again. However, the default was either the in-person or hybrid format with the

online option only available to students with accommodations in place.

Study redesign and rationale

The unanticipated shifts in instructional delivery format imposed by the pandemic restrictions led to the addition of a third group (fully online) and a corresponding reduction in the number of participants per group. This limited the statistical power of the study and comparative analyses. In response, the study was redesigned as a descriptive study focused on the instructor's experience transitioning from in-person and hybrid delivery to a fully online format within a constrained timeframe. Also included are preliminary findings on the students' perception of working with glass slides and WSI, alone or in combination.

Observations from the development of the hybrid course and research study

Hybrid learning community

The course was developed from face-to-face delivery to a hybrid format by the instructor/PI as part of a working group organized by the Center for Teaching and Learning (CTL) at OSU. This learning community spanned a quarter, and activities were delivered in hybrid format.

Central pieces in the design of the hybrid course delivery are the format and content of the syllabus for partial online delivery. It includes a definition of the hybrid format, its components and structure; approachability (language); clarity; logistics; responsibility and requirements; a transparent schedule for face-to-face and synchronous online elements; clear and easy to follow instructions and timeline(s) for independent/asynchronous work; detailed information on communication channels and times; guidance for a productive hybrid course; learning outcomes, tasks to complete, basis for assessment, grading scale; and relevant policies. The CTL provided a Canvas course template with a few basic modules that included critical design pieces that the instructor/PI found so helpful that she immediately implemented the Canvas course design in all her courses, irrespective of delivery format. Many of these elements were subsequently incorporated into a Canvas-based CTL workshop provided at the beginning of the pandemic to assist instructors with the transition to emergency remote instruction during the pandemic shutdown.

Timing and global context – Pivoting from hybrid to online delivery

The completed redesign from face-to-face to hybrid format greatly facilitated and sped up the transition to a fully online delivery. Many of the basic design elements were already in place and only needed some fine-tuning, in addition to switching face-to-face instruction from in-person to synchronous online meetings. At OSU, Zoom was the default for online synchronous interactions during the pandemic. Importantly, the heavy lifting of digitizing glass slides had already been completed; otherwise, it would have been impossible to deliver the elective in 2020. Very few students have microscopes at home and some of the key experiential elements using case material could not have been included. Group discussions are a critical element in the Histopathology Elective course and provide the Concrete Experience/Abstract Conceptualization opportunities for interpreting experiences based on Kolb's (1984) experiential learning cycle. Group discussions also support the second pair of learning opportunities, Reflective Observation/Active Experimentation (Kolb, 1984), as students listen to the contributions of others and transfer learnings to the next round of case workup. It seemed particularly critical to retain synchronous activities to support students coping with the overwhelm and sense of isolation during the pandemic.

A remaining challenge in the transition to fully online delivery was the access to WSI files. Box® was used to facilitate sharing of large files and

supported access via the internet without additional connectivity requirements. However, a big concern was the potential negative impact of slow internet and download speeds at students' locations. The instructor had large flash drives, ordered and loaded in advance of the 2020 course in preparation for the research study, and was able to offer mailing them out by regular mail quickly enough to reach students by the end of week 1 of spring quarter, in time for the course begin in week 2. In 2021 and 2022, access on Box® remained the primary mode of file sharing; however, a few students elected to check out flash drives (distributed to student mailboxes on site for pick-up during off-hours in compliance with OSU's pandemic health policy guidance). In 2021, the instructor also trialed a subscription to a virtual slide box by a commercial provider (Leica; no longer available; see Figure 6). The well-designed platform provided substantial improvement over the clumsy file sharing mechanisms. However, the annually recurring cost was prohibitive for the small program in general and an elective specifically. Now, five years into the expanding use of WSI in education, a range of options including open-source solutions are available.

Course mechanics before, during and beyond the study period

In 2020 (year before the study officially commenced), all participants including the instructor attended synchronous meetings remotely. Data transfer was sluggish, in part because of limited internet bandwidth available in rural areas of Oregon and the high demands during (pandemic-related emergency) remote instruction. The instructor screen-shared WSI via Zoom, but overall, large group discussions de-emphasized slide review and focused more on case context and diagnostic strategies.

In 2021, the instructor was able to teach on campus (OSU Corvallis); however, students still were attending group discussions online. This was facilitated by a microscope equipped with a video camera connected to laptop computer with internet access. During group discussions, the course was streamed on Zoom with the computer camera trained on the instructor and the whiteboard, and the video-feed from the microscope was screen-shared. Issues with bandwidth and speed of image transmission in the 2021 version of the meeting platform still led to considerable lag time of image projection; however, the synchronous sessions in 2021 were more similar to face-to-face delivery than the remote interactions in 2020. Independent study time was available in all delivery formats. However, the 6-ft distancing rules were still in place for all on campus activities and could not accommodate the use of dual-headed microscopes by two students simultaneously, as originally designed for in-person independent study periods. Thus, students on campus worked individually.

In 2022, OSU mandated that instructional activities occurred on campus and veterinary students were eager to return to campus and in-person instruction. Students heavily gravitated toward the hands-on use of microscopes and glass slides during independent study over WSI access and independent study online. It was very difficult to recruit participants to the hybrid and online groups of the study that year (one participant each). The effects of the pandemic and the change in the study protocol prompted the PI to further relax the design by allowing all students access to WSI, including all study participants, irrespective of their chosen course delivery format. Most students ended up using WSI to supplement note taking through screen shots and image annotations.

In 2023, fully online access was only provided in extenuating circumstances. The delivery returned to the original designed parallel tracks of in-person and hybrid format except for one student with an accommodation for remote attendance. Most students opted for in-person instructions.

From the beginning, the intent was to offer the course as hybrid course and eventually a fully online course, and the official listing with these

modalities in the course catalogue. Currently, the biggest impediment to accomplishing this goal are administrative hurdles. The very narrow definition of what constitutes a hybrid course at OSU and regimented approach disqualifies many short-duration courses, electives, and courses in professional programs from listing or cross-listing as hybrid courses.

Observations from the research study

Participants and study enrollment
Over the course of 3 years, 34 students took the Histopathology Elective course and 17 enrolled as participants in the study (5 of 17 in 2021; 5 of 10 in 2022; 7 of 17 in 2023; on average 40% of students per year). The forced (pandemic) and self-selected distribution of participants to the study groups was skewed away from hybrid (n=3) toward online (n=5) and in-person (n=9). It is not clear how much these differences in preferences were influenced by the pandemic with its forced emergency remote instruction (completely online in 2020), forced synchronous online group discussions (in 2021), mandated in-person instruction (in 2022), and the decision of the instructor to provide all participants (and students) access to WSI (2022 and 2023).

Hybrid course and study implementation
Veterinary students readily accepted and adapted to changes in delivery format of the course overall and the viewing of case material (microscopy and glass slides to WSI). In fact, ultimately and perhaps unsurprisingly, students expressed appreciation for access to the case materials in an alternate format (WSI). The two most commonly shared reasons were the facilitation of note taking and generation of personal study materials.

Limitations from issues with internet bandwidth and the image refresh-rate while screen sharing in Zoom in 2020 and 2021 and the resultant lag-time during image projection were frustrating to the instructor. However, participants did not specifically comment on this in their feedback. In 2020, this type of instruction was novel and did not allow for direct comparison by the students. In general, students require more time to orient themselves to images, locate areas of interest, collect data, and interpret observations, so perhaps they did not perceive the sluggish image refresh rates as “slowing down” or problem.

With the general return to on campus instruction after the pandemic lockdown, study participants (and students in general) immediately gravitated back to the use of microscopes and glass slides during independent study, which was surprising to the instructor given the ease of access and additional utility afforded by WSI.

In 2020, the short lead time (2 weeks) for the switch from on-campus/in-person to emergency remote instruction resulted in the cancellation of most third-year electives scheduled in the spring quarter. Overall, study participants (and students in general) expressed deep gratitude that the Histopathology Elective course was available to them in an online format. Some mentioned that this provided a sense of continuity and normalcy during very disruptive and frightening times.

Affordances and limitations provided by hybrid and online instruction

General affordances
Hybrid and online instructional modalities offer several pedagogical advantages, particularly in the context of professional education. Chief among these is the capacity for self-paced learning, which allows students to engage with course materials at times and locations that best suit their individual schedules and learning rhythms. This flexibility is especially valuable in professional programs, where students often balance demanding academic workloads with clinical and personal responsibilities. Additionally, the asynchronous availability of resources - such as digitized case materials, annotated slides, and discussion forums - enhances accessibility and supports differentiated learning strategies. These

affordances align with principles of adult learning theory, which emphasize autonomy, relevance, and self-direction.

Affordances specific to preparation for clinical work

In the context of clinical preparation, hybrid and online formats offer unique cognitive and emotional benefits. The emotional distance afforded by asynchronous case review alone or in small teams (dyads or triads) can reduce performance anxiety, particularly for students who may feel intimidated or distracted by interactions with patients and clients and real-time clinical case discussions (Fisher at al., 2014). This distancing effect allows learners more time to process complex information, reflect on diagnostic pathways, and formulate responses before sharing them verbally with the larger group and instructor or in written format with the instructor. Physical separation from the patient and client, the physical interaction with study materials, and work in teams to solve more complex problems have the potential to reduce cognitive load and thus support learning of complex cognitive tasks (Kirschner et al., 2009; Paas & Sweller, 2012). The scaffolding of cases and case work-ups into iterative cycles of independent individual/small group and large group activities of increasing complexity further enhances the development of complex cognitive skills such as clinical reasoning and communication in these lower-stakes environments, thereby supporting the development of learner confidence and competence (Kirschner et al., 2011). The synchronous discussions, whether in person at the multiheaded microscope or remotely, allow the instructor to model clinical reasoning and decision making for all enrolled students simultaneously, following the model of cognitive apprenticeship (Taylor & Care, 1999).

Limitations specific to preparation for clinical work

Research suggests that in professional curricula such as (veterinary) medicine the factors generally considered strong advantages of online education, such as 24-hour availability of instruction and independence of physical location, can be perceived by students as disadvantages (Keis et al., 2017). Primary contributing factors reported include reduced oversight and absence or reduced external limits on time commitment and timing, exacerbating poor time management and procrastination. Some may be specific to the pre-selected student population joining such programs. Keis et al. (2017) posited that the competitiveness of students in professional curricula, which typically attract high-achieving students, may be a contributing factor.

Another challenge in online education relevant to the preparation for clinical work is the facilitation of guided group discussions. In traditional face-to-face settings, students can contribute incrementally to case analyses by “thinking out loud” in a collaborative, iterative process. This dynamic is difficult to replicate in asynchronous environments, where the absence of real-time interactions can hinder the natural flow of ideas. Although synchronous remote meetings can partially mitigate this issue, they require deliberate instructional design to ensure equitable participation and timely feedback. Moreover, the immediacy of feedback from peers and instructors - critical for shaping diagnostic reasoning - is more difficult to achieve in asynchronous formats, potentially leading to misconceptions or cognitive drift, particularly in the absence of a strong feedback-seeking culture (Shafian et al., 2024).

Affordances and limitations of technology

Limitations associated with the use of glass slides

Traditional histopathology instruction relies heavily on glass slides and microscopy, which, while pedagogically rich, are constrained by logistical and infrastructural limitations. Access to microscopes and physical slides is often restricted by room availability, equipment shortages, and

maintenance costs. These constraints limit enrollment capacity and reduce opportunities for repeated practice, particularly outside scheduled class times. Equipment failure and the fragility of glass slides further complicate instructional delivery, especially in high-enrollment or resource-limited settings.

Affordances provided by the use of WSI

The integration of WSI and digital slide scanning technologies has addressed many of these limitations while also introducing new pedagogical affordances. Annotated digital images facilitate guided learning by allowing instructors to highlight key features and provide embedded commentary. In this cognitive apprenticeship model of instruction learners benefit from expert modeling and scaffolded feedback (Collins et al., 1989). Students can enhance their note-taking practices by capturing screenshots and adding personal annotations, thereby reinforcing learning through active engagement and reflection. The use of WSI also promotes consistency in instructional materials and enables asynchronous review, which is particularly beneficial in hybrid and online formats.

Limitations associated with the use of WSI

Not all participants agreed that WSI provided a direct benefit to their learning and learning experience. Some of the cited limitations reported by participants were the additional time commitment and technical challenges associated with downloading and viewing WSI and the lower resolution of WSI compared to glass slides, especially for cytology slides (which are usually viewed under oil immersion). This emphasizes the point that the incorporation of technology does not automatically enhance learning but rather requires a deliberate approach to the selection and implementation of technology and integrated course design (Chickering & Ehrmann, 1996).

Budgetary and technological considerations

The transition to digital pathology instruction necessitates significant technological infrastructure. Essential components include slide scanning equipment or access to (commercial) scanning services, as well as a reliable platform for hosting and viewing large image files. These platforms must support high-resolution image rendering, annotation capabilities, and secure access for students and instructors.

The implementation of such technologies is not without challenges. The large file sizes associated with WSI pose storage and bandwidth issues. To manage data volume, a combination of low-resolution overview scans and high-resolution images of key areas can be employed. Additionally, disparities in internet access among students can hinder equitable participation. During the COVID-19 pandemic, for example, flash drives containing course materials were mailed to students with limited internet connectivity, highlighting the need for flexible and inclusive technological solutions.

Impact on teamwork, peer teaching, and group discussions

The shift to remote instruction during the pandemic significantly impacted collaborative learning dynamics. Students reported a reduction in the spontaneity of group discussions, which are typically characterized by fluid exchanges and nonverbal cues. During the pandemic, especially early on, students had the tendency to keep cameras off in remote instruction settings. Facial expressions and body language including hand gestures have been shown to support learning (Novack & Goldin-Meadow, 2015). The implementation of “camera-on” policies fostered engagement and accountability. Despite these efforts, the richness of an in-person interaction was difficult to replicate in synchronous online sessions.

Nevertheless, students in general and study participants specifically demonstrated resilience and adaptability by developing their own strategies to communicate and collaborate. These included the use of messaging apps, shared documents, and informal video calls to facilitate group work. While effective to some extent, these strategies required additional effort and coordination, underscoring the importance of intentional instructional design in supporting peer teaching and teamwork in online environments.

Embodied cognition

Embodied cognition emphasizes the integral role of sensory and motor processes in the development and execution of cognitive functions. Research suggests that haptic experiences significantly enhance learning outcomes by engaging multiple sensory modalities, thereby facilitating deeper understanding and retention of information (Wilson, 2002; Barsalou, 2008). These tactile interactions are particularly crucial in fields requiring precision and manual dexterity (Glenberg, 2010). The incorporation of hands-on experiences into educational frameworks to bolster embodied learning not only enriches the educational experience but also prepares students for real-world applications, ultimately fostering a robust and practical skillset (Paas & Sweller, 2012).

The relevance of embodied learning was clearly demonstrated in the Histopathology Elective course. Following the return to in-person and hybrid instruction, students gravitated toward the use of microscopes and glass slides during independent study. This preference underscores the irreplaceable value of tactile engagement in developing diagnostic acumen and reinforces the need to preserve hands-on components in hybrid and online course designs whenever feasible. Research shows that embodied cognition is especially impactful in domains requiring manipulation of objects and observation of human actions (Castro-Alonso et al., 2024) and in fields where bodily awareness, sensorimotor integration, and emotional attunement are essential (Francesconi & Tarozzi, 2019), all central to medical training and the medical profession.

Modality considerations

The pandemic forced a pivot from in-person and hybrid to fully online course delivery. One of the major benefits, aside from keeping everyone safe, was the increased accessibility and flexibility afforded by hybrid and fully online instruction especially to students with additional demands in their lives such as families, disabilities, or concurrent employment. At the tail end of the pandemic, academic institutions were eager to return to in-person instruction, often eliminating online components. The expanded menu of hybrid and fully online educational opportunities developed in response to the pandemic provides improved accessibility, affordability, and flexibility, and may, ultimately, capture a broader segment of the population as potential learners. A remaining challenge in online education are solutions supporting haptic experiences that drive embodied cognition and the honing of skills still critical in many professions and areas of work at this time (Loginov et al., 2022).

It is important to note that the adaptation of the Histopathology Elective course during the pandemic was not just a switch to emergency remote instruction. The redesign of the course for hybrid delivery, with full integration of online and in-person elements, allowed the replacement of in-person with synchronous online elements while keeping the pedagogical integrity of this instructional unit intact. If designing a course or activity for full online delivery seems too daunting or impossible, a stepwise approach may involve the initial redesign to hybrid delivery with subsequent replacement of remaining in-person pieces as technology becomes available, accessible, and/or affordable.

The adaptability and willingness of the students to try new instructional modalities is inspiring. Veterinary students readily accepted and adapted to the changes in the delivery format of the course

overall and the viewing of case material (microscopy and glass slides to WSI); in fact, students expressed appreciation for access to the case materials in an alternate format. The addition of a database and WSI viewing without the need to download specific software is currently being implemented and will provide easy access and convenient viewing of WSI from practically anywhere.

Conclusions

The transition from in-person to hybrid and fully online delivery of the Histopathology Elective course at OSU provided a unique opportunity to examine the technical and pedagogical affordances and limitations of various instructional modalities in a professional curriculum. Hybrid and online formats offered increased flexibility, accessibility, and opportunities for self-paced learning, while also supporting emotional distancing from patient care, facilitating reflective clinical reasoning. However, these benefits were tempered by challenges in fostering spontaneous group discussions, delivering immediate feedback, and replicating the embodied learning experiences critical to clinical skill development.

Technological innovations such as WSI and digital annotation tools mitigated some of the logistical constraints associated with traditional microscopy, but introduced new challenges related to data management and equitable data access. Budgetary and infrastructure considerations remain significant barriers to widespread adoption, particularly in resource-constrained settings.

Ultimately, the experience of transitioning the course highlights the importance of intentional instructional design, institutional support, and pedagogical flexibility. While hybrid and online modalities can enhance educational access and engagement, they must be thoughtfully integrated with tactile, collaborative, and reflective learning opportunities to fully support student development in professional and clinical contexts.

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Appendix A. Current approaches to the delivery of instruction – definitions and theoretical grounding.

Mode	Definition	Theoretical Grounding	References
In-Person	Instruction where students and instructors are physically co-located, typically in a classroom setting, emphasizing synchronous, real-time interaction.	Constructivist and sociocultural learning theories (e.g., Vygotsky, 1978); supports active and collaborative learning.	Johnson, N., Seaman, J., & Poulin, R. (2022)
Face-to-Face	Direct interpersonal interaction between teacher and students, typically in physical classrooms but may include synchronous video-based formats.	Dialogic pedagogy and humanistic education theories (e.g., Rogers, 1965); emphasizes presence and communication.	Stern, B. S. (2004)
Online	Instruction delivered entirely via the internet, either synchronously or asynchronously, using digital content and tools.	Connectivism (Siemens, 2004; Downes, 2012), cognitive load theory; emphasizes networked knowledge and learner autonomy.	Johnson, N., Seaman, J., & Poulin, R. (2022)
Remote	Teaching where instructor and students are separated by distance and rely on technology, often used in emergency contexts.	Universal Design for Learning (UDL); may lack the design rigor of formal online education.	Hodges, C., Moore, S., Lockee, B., Trust, T., Bond, A. (2020)
Hybrid	Structured blend of in-person and online components, intentionally integrated to support learning outcomes.	Blended learning theory, constructivist approaches; supports flipped classrooms and differentiated instruction.	Johnson, N., Seaman, J., & Poulin, R. (2022)
Mixed Modality	Use of multiple instructional methods (e.g., in-person, synchronous online, asynchronous) within a course, offering flexibility.	Learner-centered and personalized learning frameworks; supports self-regulated learning and choice theory (Glasser, 2011).	Johnson, N., Seaman, J., & Poulin, R. (2022)

About the Research Unit at Oregon State Ecampus

Vision

The Ecampus Research Unit strives to be leaders in the field of online higher education research through contributing new knowledge to the field, advancing research literacy, building researcher communities and guiding national conversations around actionable research in online teaching and learning.

Mission

The Ecampus Research Unit responds to and forecasts the needs and challenges of the online education field through conducting original research; fostering strategic collaborations; and creating evidence-based resources and tools that contribute to effective online teaching, learning and program administration.

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