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The Evolution of an Online Geoscience Lab Course: Experiences from a Regional University

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Abstract

This article seeks to provide a template for faculty to address the challenges of teaching an online lab science course and the efforts of faculty and staff to ensure quality, academic integrity, and student success by relating our university's experience in developing and continuing to evolve our geoscience lab course for online delivery over twenty years. After a brief review of the literature surrounding the pedagogy and challenges of teaching online lab science course, the bulk of this article will address UT Martin's path navigating from early iterations of general education Geology lab courses to the versions offered currently.
Keywords: online Geoscience lab course, experience

1. Introduction

The University of Tennessee at Martin (UT Martin) is considered a primary campus of the University of Tennessee system and is the only public university in West Tennessee outside of Memphis. UT Martin is designated as a master's level institution, with five academic colleges offering 18 undergraduate degree programs and over 100 special programs in support of those degrees. Furthermore, UT Martin has an extensive history of serving students through online courses and programs.

In the late 1990s, UT Martin was tasked with being the home of UT Online and housed the whole University of Tennessee System's online programs. Faculty from across the system, from UT Martin, UT Knoxville, and UT Chattanooga, began developing and teaching courses in general education requirements for all three institutions. Continuing the University's original mission as a land-grant institution to open educational opportunities to thousands of farmers and working people previously excluded from higher education, UT Online tasked itself with providing access to adult learners and students unable to attend in-person in Martin, Knoxville, or Chattanooga. As enrollment in the courses grew, the need for full degree programs became increasingly apparent and required faculty from all general education disciplines to develop online courses to promote student progression.

To support this student demand, UT Online began strategizing for what was then called the Bachelor of University Studies (BUS) degree and is now known as the Bachelor of Interdisciplinary Studies (BIS). The BUS/BIS program offers students the freedom to explore a wide range of subjects and the opportunity to tailor their studies to specific areas of interest. It was created specifically with adult learners and non-traditional students in mind, and, therefore, being able to offer the program completely through asynchronous online courses greatly benefited that student population.

UT Online needed to offer the whole gamut of general education courses along with upper division offerings to successfully have a completely online program. The successful offering of lab science courses online was paramount so designing labs that could be completed from a student's home within the flexibility of an asynchronous course was one of the first challenges undertaken in 2000.

After successfully establishing online offerings for the requirements of the BIS degree (2000), other undergraduate programs followed suit with a BSBA Management program first being offered completely online in 2004 and the Bachelor of Agriculture: concentration in Agricultural Business coming fully online in 2010. Additionally in 2004, UTM's first three completely online graduate programs were established offering as master's degree in agriculture and Natural Resource Management, master's in education, and master's of Family and Consumer Science. Today, UT Martin offers ten undergraduate programs and twelve graduate degrees completely online.

This article seeks to provide a template for faculty to address the challenges of teaching an online lab science course and the efforts of faculty and staff to ensure quality, academic integrity, and student success by relating our university's experience in developing and continuing to evolve our geoscience lab course for online delivery over twenty years. After a brief review of the literature surrounding the pedagogy and challenges of teaching online lab science course, the bulk of this article will address UT Martin's path navigating from early iterations of general education Geology lab courses to the versions offered currently.

2. Literature Review

There are many reasons for faculty to offer online courses, but one of the most prominent is to help deliver course content to students who cannot attend main campus. As online tools and delivery platforms become more seamless, the ability to expand online courses beyond traditional non-lab courses. In the past, teaching lab related courses in an online environment was limited because of the hands-on nature of the content, that relied on controlled lab experiments.

While literature is limited around the development and use of online geoscience lab courses, there are relevant findings form previous works that supports the importance of online education in the geosciences area. Feig (2010) discussed the importance of translating courses to a digital format from a traditional face to face classroom. Two issues discussed focused on the availability of samples for use in online labs. The handling of material has always been an important part of the process and this needs to be addressed in any online lab offering. Use of

sample materials need be done in a cost effective and timely manner. Secondly, the issue of quality control needs to be addressed. With all forms of teaching, quality must be maintained regardless of the teaching medium. The development of the

The general acceptance of online courses continues to grow in popularity. In 2021, nearly 8.5 million college students took online courses according to the National Center for Education Statistics (Hamilton, 2023). The popularity and convenience of online courses have driven universities to expand online offerings to and degree programs. A common issue related to online delivery is what to do with the lab courses needed for science related courses. Conveying facts, figures and concepts can be delivered online, but what do you do to develop the practical application of concepts into practice? For science related disciplines, the application is found in the lab aspect of the course and faculty are keen for students to interact with the material and equipment. Developing experiences online can be difficult, but as education technology improves faculty have been able to better simulate the on-campus lab experience (Waldrop, 2013). Developing labs in the sciences has common issues regardless of discipline (whether, chemistry, biology, or geosciences, etc..). Faculty in the geosciences can learn from findings in similar areas such as biology. Zhou 2020 found online tools can provide faculty with multiple opportunities to engage students with the course material that leads to student learning. However, found that a hybrid design to supplement face to face teaching works better in the biology setting. Zhou's development of the lab structure of including prelab assignments, in lab experiments, and some type of reflection after the lab is ia useful model for developing online lab experiences for students. The use of lab kits that are sent to student homes have been explored and found to be useful. A recent study reported that a lab in a box showed promising results for online students taking an online biology course. Students responded positively to the hands-on nature of the exercise and the ability to have longer periods of access to the material, not just during a singular defined lab time (Novo, et.al., 2021). In addition to lab kits, Ballero 2019, demonstrated that while in person specimens are of higher quality, it is possible to the use high quality digital images in online geology lab settings. These images need to be of high resolution and quality and in two- and three-dimensional formats. The authors have used similar images in the development of the online lab materials for the course developed at UT Martin.

Background of Online GEOL 110

The University of Tennessee at Martin began offering Physical Geology 110 in an online format in 2000. Students accessed a web-based learning management system (LMS), which at that time was Blackboard, for PowerPoints, lab assignments, notes, and to ask questions. At that time, technology for online learning, while not very advanced nor sophisticated, was still a considerable improvement compared to original correspondence courses. Online instructors utilized a type of primitive screen capture program native to Blackboard and recording functions available in Microsoft PowerPoint. This enabled faculty to provide short voice over recordings for online instruction of Physical Geology 110. For the lecture portion of the course, abbreviated video recordings explaining and emphasizing important topics found within provided PowerPoints. For labs, voice overs were used for short explanations of lab activities and how to work a particular problem. In the early 2000's, many of the recordings were

purposely kept short in length because broadband internet service was still in its infancy. Many online students at that time were still using dial up service for internet connectivity which made the use of long video recordings or large computer files for download just not feasible. Students drew upon a combination of lab work and exams utilizing a traditional paper format with the included implementation of online quizzes. Daily grades of lower point values were delivered online while exams, for lecture and lab, still required a proctor or testing center. Depending on the technological availability of the proctor or proctoring service, students would either complete their exams online or were provided with a paper copy to complete.

By the mid to late 2000's the combination of improved computer technology with faster and more reliable internet service allowed our instructors to utilize additional online content for Blackboard. Explanations for lecture and lab content were more in-depth because online instructors were not as limited by technology. Students could access both PowerPoints and watch full recorded lectures of that same material within Blackboard. Lecture exams and the lab midterm and lab final still required a proctor or testing service. In 2015, UT Martin transitioned to a different LMS called Canvas. The shift to this new LMS occurred entirely to promote student success by ensuring sound online instruction through the implementation of the latest online learning technologies. Staying abreast of the latest technology is not only what students expect but also aids in presenting key geological concepts. For example, integrated and more robust recording and presentation software, group project interfaces, in-video quizzes, discussion board tools, and the ability to create and embed a full range of Open Educational Resources (OERs) all engage students more than the correspondence style courses of the past.

For these reasons, UT Martin transitioned to Canvas in Fall 2016. Blackboard's user interface had stagnated, and many students reported issues navigating the LMS. Additionally, at that time, Blackboard was more limited in how it integrated with other third-party software and closed to institutional customization. In stark contrast, Canvas's coding is open-sourced meaning that anyone can see the coding, test for vulnerabilities, and, perhaps most importantly to us, utilize the coding to create software to integrate with the LMS. The transition to Canvas provided an opportunity to expand the toolkit provided to faculty. UT Martin added web-based screen capture and recording software to allow all faculty to easily create and edit lectures for their online courses, two options of proctoring software to ensure academic integrity, a discussion board tool with robust features, along with several other pieces of software to support student success and engagement.

The transition to Canvas also provided an opportunity for faculty development training on online pedagogy and best practices. Being in the Summer of 2016 and continuing annually, UT Martin Online Programs partnered with the Instructional Technology Center (ITC) to provide week-long faculty workshops that focus on basic and intermediate skills of online teaching. Interested faculty completed a survey (i.e., application) regarding their use of current tools and the intended course that they wanted to create or redesign. Participation in each session is limited to 20 – 30 faculty to ensure faculty have opportunities for one-on-one guidance. The design of the workshop models best practices in online teaching. A rubric based on Quality Matters online course design is used to assess the work that each participant

produces during the week. Payment of the workshop stipend is contingent upon scoring a specified score on the rubric. The content is delivered with a combination of pre-workshop online activities, speakers, videos, assignments, and concurrent sessions. Faculty are also given time each day to work on their courses with ITC and UT Online staff available to offer feedback and direction.

After noting the benefits of the first workshop, a second workshop was designed for faculty who had previously attended the basic workshop in the past and who had demonstrated proficiency in online teaching. The workshop was limited to three days in the summer, but the work extends into the fall semester. Similar to the basic workshop, content is delivered through a combination of pre-workshop online activities, speakers, videos, assignments, and concurrent sessions. A more advanced rubric is used to assess the work that each participant produced at the end of October. Payment of the workshop stipend was contingent upon scoring a specified score on the rubric. Participants were also assigned to a Teaching Square (TS) of four colleagues. Teaching Squares is a professional development program that has been used widely in higher education to develop a small community of professors who observe their TS members' in-person classes for self-reflection – as opposed to evaluation and critique. The framework requires that each team member set goals for what they want to learn from the experience from their colleagues. The TS model was adapted for this workshop to allow faculty to observe their colleagues' online courses. Each TS met during the July workshop, discussed preliminary goals and scheduled follow-up meetings in the fall semester.

How We Teach a Geology Course Online

The difficulty teaching any lab science online is how to effectively deliver lab content in lieu of traditional face-to-face instruction. We strive to offer our web-based geology course in a manner equal to what our face-to-face students receive. The methods used by our instructors have developed as advances in online educational technology have occurred. Originally, face-to-face teaching was the benchmark for online education and the chief criticism from our university faculty was that online modality was inferior to traditional face-to-face education. While those concerns have been quieted over the past few years, at the onset of my development of the online geoscience lab courses, the objective was to ensure that my students' lab experiences and learning outcomes were as similar as possible to the face-to-face labs as possible.

Lecture

Initially, development of online courses merely involved an attempt to upload most of course material from face-to-face courses online in the university's learning management system. However, it became evident that simply placing content on a web-based platform did not equate to effective online instruction. To address this, short instructional videos were created to support both lab and lecture materials. Delivering geology lectures through web-based platforms proved to be a more straightforward process. Initially, PowerPoint presentations were posted, supplemented with additional notes when covering topics historically challenging for students. As technology evolved, screen-captured recorded lectures were incorporated alongside the PowerPoint slides.

Faculty development training highlighted the instructional strategy of chunking information which involves breaking down complex content into smaller, more manageable "chunks" or segments. The process involves: identifying key concepts, organizing content to focus on one key concept or skill, limiting the size of the chunk to 20 - 30 minutes (which aligns with the attention span of most learners), providing summaries and short videos content, and opportunities for quick feedback and assessment. While the content of recorded lectures evolved in response to changes in textbooks and chapter content, the instructor's consistent approach to presenting new material remained unchanged. Furthermore, supplementary short PowerPoints containing a series of topical questions and answers were made available to students. These questions not only aided in comprehension of geological concepts but also served as valuable review material for lecture exams.

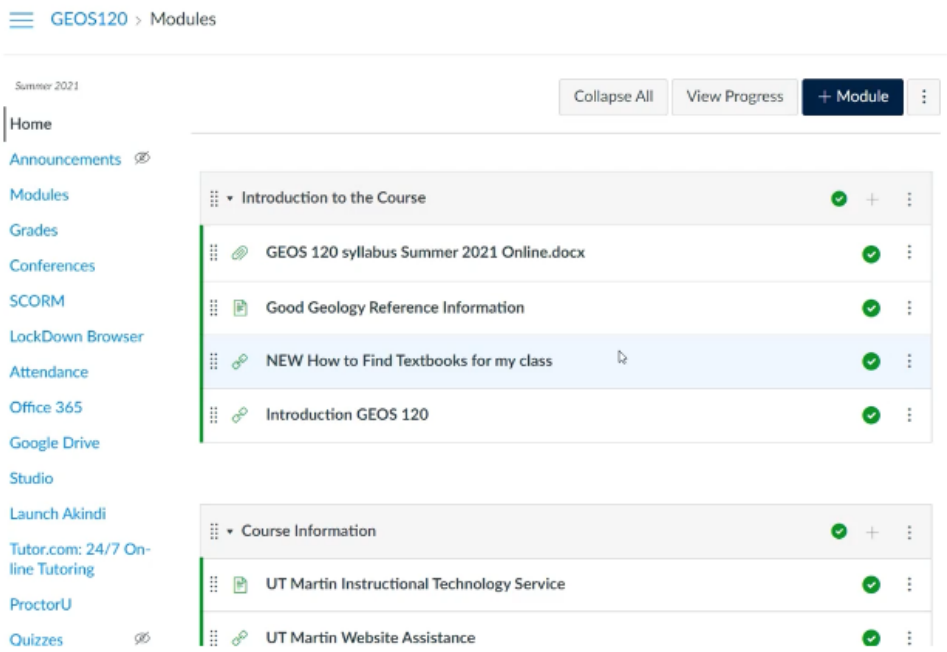

Figure 1. Image from Introduction to Course video

Labs

Moving geoscience lab activities online required multiple iterations of trial and error to determine what knowledge could students absorb and apply without a faculty member alongside them to facilitate the lab in real-time. It took time to develop an efficient approach to delivering geology lab content via online platforms, and it was impossible to anticipate all the unique challenges that students would face completing their labs at a distance.

For instance, when assessing students' mineral identification skills, the initial assessments utilized fill-in-the-blank questions in hopes of requiring more authentic assessment from students. However, instructor feedback to fill-in-the-blank questions proved problematic due to the numerous ways students might respond to ambiguous queries. Differences in students' descriptions along with misspelling and capitalization errors stagnated the auto-grading of the learning management system and slowed student feedback to a deliberate, manual process –

the exact opposite of the goal to provide instantaneous feedback to online students. To address these glitches, a transition was required to multiple-choice, true/false, and matching questions as the primary methods of evaluating student comprehension.

While certain materials from traditionally taught geology labs, such as mineral and rock identification, were straightforward to adapt for online instruction, other topics posed greater challenges. Subjects like flooding, groundwater, and topographic maps were particularly challenging to teach online due to limitations in providing time-sensitive feedback. To alleviate this issue, concise video recordings explaining key concepts and providing examples for completing lab assignments were added. Later additions include worked-out examples with step-by-step explanations and practice questions allowing students to self-assess their understanding. To further benefit student success, synchronous virtual meetings were added providing students the option to receive instantaneous feedback and instruction on particularly challenging topics.

Another recurring challenge faced in geoscience courses regardless of modality is student difficulty with general mathematics concepts and a need for remediation. These students may comprehend the geological content but inability to correctly apply general mathematics prevents them from success. For instance, while students might grasp the concept of stream gradient, they often encountered difficulties when asked to solve stream gradient problems or convert measurements between standard and metric systems. To facilitate student success, introductory and remedial content was added to the online course including instructor videos, third-party content, and practice problems. An additional resource that resulted from the pandemic was all students having access to 24/7 online tutoring.

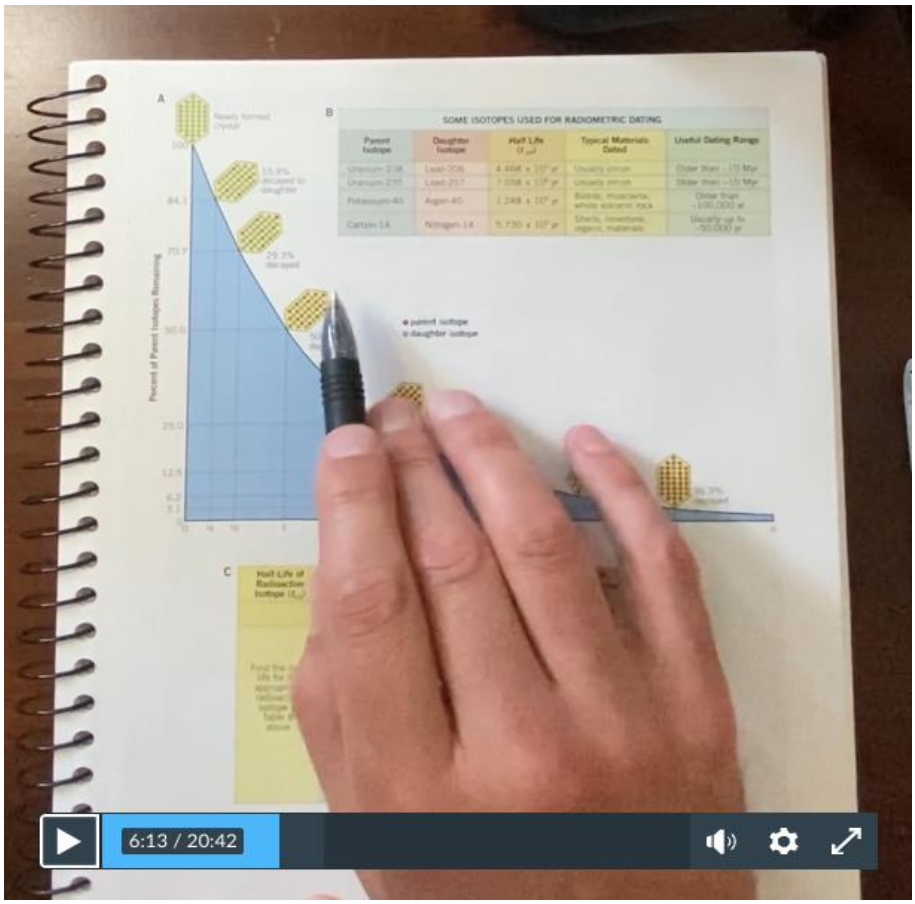

Figure 2. Image from video explaining Geologic Time Lab

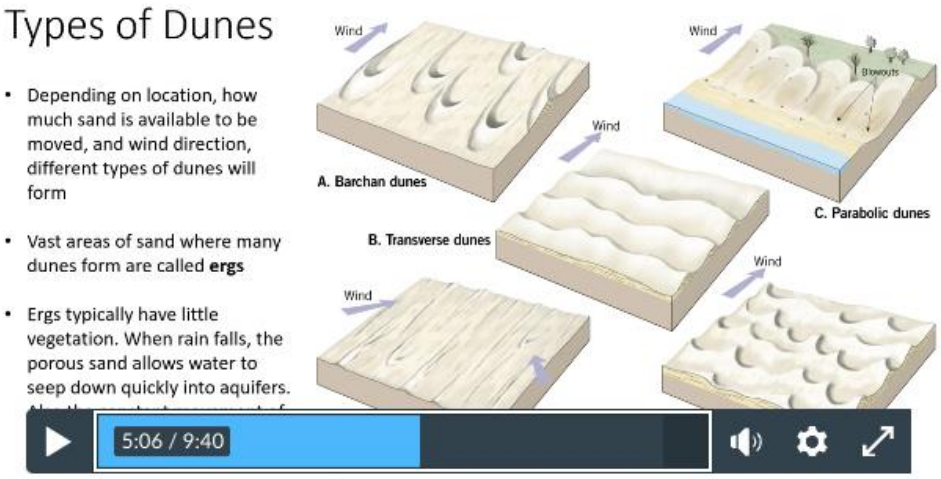

Figure 3. Image from video for Desert Lab

Regarding mineral and rock identification labs, replication of on-campus labs was much easier; however, challenges came from the coordination of getting these materials to the students. Originally the university put together its own rock and mineral kits to mail to students. While this practice ensured students received the correct samples in a timely manner, it proved

unscalable and cost prohibitive. The next iteration of lab kits came from a small business which created custom kits and mailed them directly to our students; this method worked well until the pandemic forced their company out of business. Currently, a larger company provides standardized kits. This approach helps with cost effectiveness and removes supply concerns but comes with its own challenges. These kits are not customizable and come with the inclusion of a sheet identifying all the rocks and minerals which would counterattack the point of identification labs, so all the kits are first shipped to the university where the identification sheet is removed before shipping the kit to students.

Figure 4. Lab Kit Pictures

Other logistical difficulties with the kits occurred when we tried to send out a smaller, secondary set of rocks and minerals for identification on the final exam. Unfortunately, inability to customize the kit along with time constraints, cost concerns, and issues with expecting students to return these exam kits. As an alternative, the final exam questions over mineral and rock identification include pictures of samples from the kits along with corresponding terminology used in the identification process. Also, students can keep the kits removing logistical concerns with returning materials.

3. Conclusions

Moving forward, the goal is not only to enhance the quality of online lab experience but also to align them closely with their face-to-face counterparts, so students have a common experience no matter which modality they choose. The widespread adoption of hybrid teaching models and flipped classroom pedagogy during the pandemic made this goal more attainable. During the pandemic, face-to-face labs added multiple components to the learning management system for on-campus courses including short pre-lab instructional videos, reading materials, and pre-lab quizzes. Students complete all the pre-lab components before coming to the lab where an instructor briefly reviews the online materials before being in the lab. This frees the instructor to have more one-on-one interactions with students during the labs. With on-campus labs becoming more hybrid in nature, the opportunity to tweak our online labs to align will hopefully benefit student success by ensuring s high degree of familiarity for students transitioning across modalities either from on-campus courses to online or vice versa.

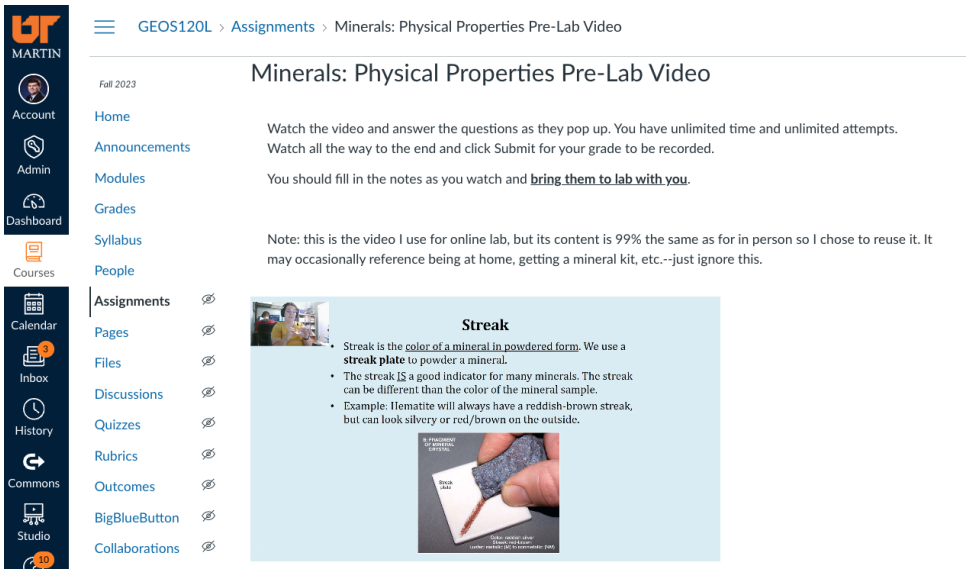

Figure 5. Face-to-face minerals lab Pre-Lab video

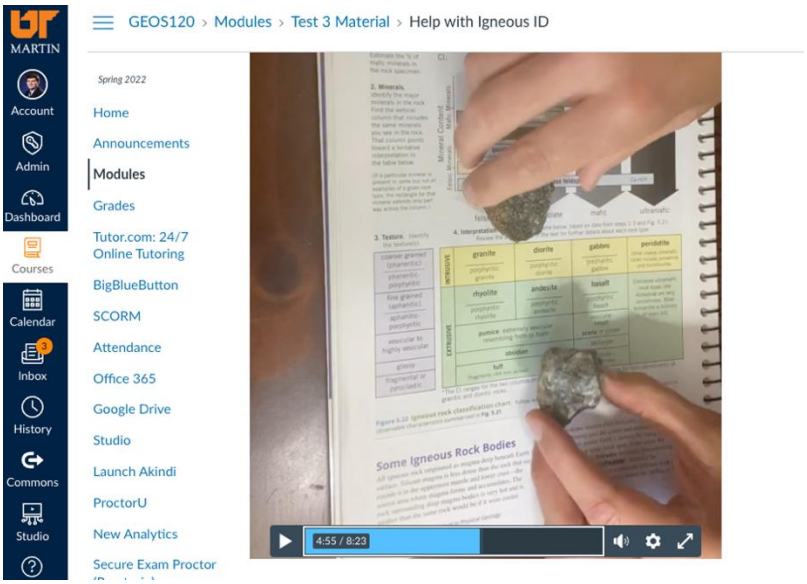

Figure 6. Face-to-face minerals lab Pre-Lab video

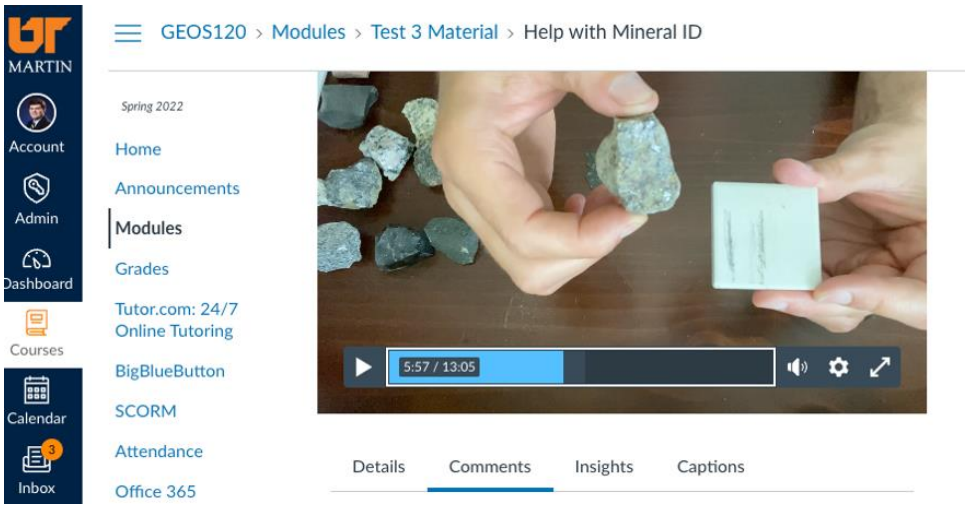

Figure 7. Online course rock and mineral lab instructional video – note the similarities to the face-to-face resources now being offering in a flipped-classroom or hybrid pedagogy

Future research endeavors will address evolving technology, including artificial intelligence, that will facilitate increased student-to-student and student-to-faculty interaction. The presented model can be extended to encompass lab science courses, as the challenges and solutions associated with delivering online lab experiences are universally applicable across disciplines. Future avenues of research will include tracking student outcomes for the online sections versus traditional on campus to develop a better baseline for future changes in the course delivery. While students enrolled in programs delivered 100 percent online, may differ from traditional on campus students, it is important to make sure that the quality of the content is suitable for all types of students. This will continue to be a need area as the need for online courses increases among on campus students. In addition, the samples kits will need to be evaluated routinely to determine if they are economical and can be provided in an efficient

manner. This is an area that the university might consider developing in house, but more information needs to be collected on potential impacts of such a move.

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Authors contributions

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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