An Online Introductory Physical Geology Laboratory:
From Concept to Outcome

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ABSTRACT

Networked computing presents opportunities for innovation in geoscience instruction. Many institutions are hybridizing their introductory courses or offering them completely online. However, a key challenge in the geosciences is that of adapting laboratory classes to the online environment, particularly with regard to teaching mineral and rock specimen identification. This contribution discusses the design and implementation of an online introductory geology laboratory at the University of Louisiana at Monroe, including curriculum, materials, assessments, and delivery of instruction. Results are presented from a pilot study comparing student outcomes of both an online section and a traditional, face-to-face (F2F) section. No significant differences in assessment outcomes were found between a face-to-face control group and an online experimental group. Recommendations are presented for instructors and institutions that may be considering online laboratory instruction.

INTRODUCTION

The terms "online learning" and "computerized instruction" are readily understood to imply the use of computers, the Internet, and course management software (e.g., Blackboard or Moodle) by students and faculty in the learning environment. The more formal term of "cyberlearning" has been coined by the National Science Foundation's Cyberlearning Taskforce, which defines cyberlearning as "learning that is mediated by networked computing and communications technologies" (Borgman et. al, 2008 p. 5). College and university departments and faculty are increasingly exploring cyberlearn-

ing as a method to increase enrollments and reduce costs. Institution-wide efforts may be adopted in an effort to expand offerings beyond the home campus. Such efforts are generally not driven at the departmental level. As a result, geoscience faculty may feel particularly adrift in the process, owing to the fact that as a discipline, the geosciences are intensively oriented toward hand specimens and in-person, field-based learning. Few resources exist that are specific in tailoring geoscience curricula to online environments, whether those resources are in the form of simple "advice" to explicit examples of "converted," or "translated" courses.

A key concept of cyberlearning is the translation from traditional, face-to-face (F2F) environments to those that are technologically mediated. Translation is the process faculty undertake when determining how a course will be administered in a cyberlearning environment. Translation issues include how course objectives and learning outcomes will be met and assessed in the new environment. Translation also includes content delivery, i.e., how lectures, lab exercises, and discussions will be delivered in the cyberlearning environment. Once translated, cyberlearning courses must be comparable to F2F courses.

Various workers have addressed these questions. Swan (2002) reported a strong positive correlation between course structure and student learning in online settings. Other workers (e.g., Jiang and Ting, 2000; Tomasik et al., 2008) report positive correlations between levels of student-faculty interaction and with student success and satisfaction. The Quality Matters Consortium has created a rubric for standardizing quality control in online environments (Qualitymattters.org, 2008). The consortium is composed of faculty from various U.S. universities. Quality Matters is a peer-based certification process, intended to provide institutions with a "baseline" of uniform quality-assurance for online courses. Institutions can subscribe to the rubric and work with external evaluators

who advise the institution on its implementation of online course delivery. These evaluators will also certify that the institution's efforts are compliant with the rubric. The rubric consists of 40 standards applied across eight domains. These standards address practical issues such as course navigation, access for students with disabilities and the use of assessment and accountability tools. The rubric also addresses the institutional cyberinfrastructure for the course, including how students obtain technical support and how the course is delivered. The rubric does not dictate course content.

In the geosciences, most translation to cyberlearning is taking place at the introductory level (e.g., Thomas and Nelson, 2008) and in advanced undergraduate field courses (e.g., Guertin and Bodek, 2008). Translation of the introductory physical geology laboratory presents two basic issues to geoscience educators. The first issue is centered on practical and logistical concerns. Laboratory course exercises rely on collections of mineral and rock specimens, as well as topographic and geologic maps. Hand samples are a particular concern: How are the multisensory skills required of mineral and rock identification taught in a cyberlearning environment? How do off-campus students access specimen collections? How is this done in a cost-effective manner? The second issue is one of quality control. Translating a course into a cyberlearning environment should not significantly alter or reduce neither its objectives nor its expected learning outcomes. Cyberlearning and F2F sections should compare well in terms of activities, materials, assessments, and learning outcomes.

Certain lab activities can be easily translated and compared between environments. For example, Grant and Benson (1997) include an activity in their lab manual where students locate an earthquake epicenter using paper, rulers, and compasses. Novak (1999) produced an epicenter-location activity for students, but in an entirely online format. Epicenter location is fundamentally a computational activity,

whether those computations are done by hand or by computer. However, hand specimens cannot be digitized. They can only be represented by digital images and descriptions.

In 2007, the introductory-level Physical Geology Laboratory course offered at the University of Louisiana at Monroe (ULM) was translated into a cyberlearning environment. The translated lab course was intended to reproduce, as faithfully as possible, the instructional environment of the F2F labs. Video segments and HTML tutorials express a teaching persona. The same assessments were used in both the F2F and online labs; paper quizzes were converted to electronic ones. Cyberlearning students used hand specimens that closely resembled the specimens used in F2F sections. Some of the cyberlearning kit specimens were purchased, but a majority of them were from the existing ULM specimen collections. A student worker processed over four thousand pounds of minerals and rocks for the kits.

A description of the translated class is provided below, including a discussion of hand-sample access, distribution, and cost. The results of a pilot study are presented, which compared selected learning outcomes of a cyberlearning laboratory section and a F2F laboratory section. The two courses are compared in terms of assessments, learning outcomes, and course objectives. Finally, suggestions for future laboratory translations are provided.

DESIGN OF THE TRANSLATED COURSE

The lab course at ULM was administered during a four-week summer session in an asynchronous format in the Blackboard v.5 environment. For rock and mineral labs, students were required to simultaneously use online tutorials, a hand specimen kit, and instructional video on DVD. For remote sensing and mapping labs, students simultaneously used topographic and geologic maps, image processing freeware, and online tutorials. This course was largely predicated on student commitment to integrated use of their materials. All online courses at ULM conform to the standards outlined in the Quality Matters rubric (Qualitymatters.org, 2008).

Course Materials

Each student received the following materials via postal mail:

- DVD disk with instructional video segments
- CD-ROM data disk
- "Southeast Region Geologic Highway Map" from AAPG

- "Goldfield Nevada-California" USGS Topographic Map
- Hardness kit and streak plate
- Box set of 33 mineral and rock specimens

The DVD contains video segments to accompany the tutorials on Blackboard. The segments can be viewed on either a computer or on a home DVD player. As students navigated the online tutorials in Blackboard, they saw prompts such as, "*Watch the 'Sorting Minerals' video clip on the DVD now!*" Once students finished watching a particular segment, they were to continue with the online tutorial. Each segment is a few minutes in length and designed to be more relaxed and informal than the tutorials. The video segments were recorded by a student worker, and hosted by a ULM Geosciences faculty member. Roxio Creator 9 software was used for editing and post-production. ULM undergraduates appear in the videos, and in one segment, the president of the university engages in a mineral sorting activity. Figure 1 shows a screenshot of the DVD menu screen.

The CD-ROM contained duplicates of the online tutorials, additional worksheets, informational links, the Erdas ViewFinder remote sensing freeware (Erdas, Inc., 2007), and LANDSAT images of the Goldfield Quadrangle, Nevada. The Southeast Region Geologic Map was from the Highway Geologic Map series produced by the American Association

of Petroleum Geologists (Behravesh et al., 1995). The Goldfield Nevada-California map is a 1:100,000 scale topographic map (USGS, 1985). The hardness kit contained a beveled glass plate, a steel nail, a penny, and a standard streak plate. This kit also contained a length of string for use in the map labs. The kit did not contain a solution of hydrochloric acid because 1) the kit was to be mailed, and 2) use of acid would not be supervised.

The rock and mineral kit is shown in Figure 2. The kit contained eleven minerals: Azurite, biotite, calcite, halite, magnetite, malachite, microcline, muscovite, olivine, plagioclase (var. albite), and quartz. The ten igneous rocks were granite, diorite, gabbro, porphyritic andesite, pumice, obsidian, welded tuff, basalt, rhyolite, and scoria. The six metamorphic rocks were gneiss, schist, phyllite, slate, marble, and quartzite. The six sedimentary rocks were limestone, chert, dolomite, conglomerate, sandstone, siltstone, and shale. Individual specimens were not labeled. Igneous rocks were referred to as "Rock Type 'A'"; metamorphic rocks were referred to as "Rock Type 'B'"; and sedimentary rocks were referred to as "Rock Type 'C.'" "Rock Type" labels were affixed in the trays under specimens that started a new section. The rationale for not labeling individual specimens was that students were required to familiarize themselves with rock textures before learning rock names.

Figure 1. Screenshot of the main menu from the instructional DVD.

Figure 2. Four views of the distributed specimen kit. (A) Mineral specimens, identified as such to students. (B) Specimen kit with igneous rocks highlighted, identified to students as "Rock Type A." (C) Specimen kit with metamorphic rocks highlighted, identified to students as "Rock Type B." (D) Specimen kit with sedimentary rocks highlighted, identified to students as "Rock Type C."
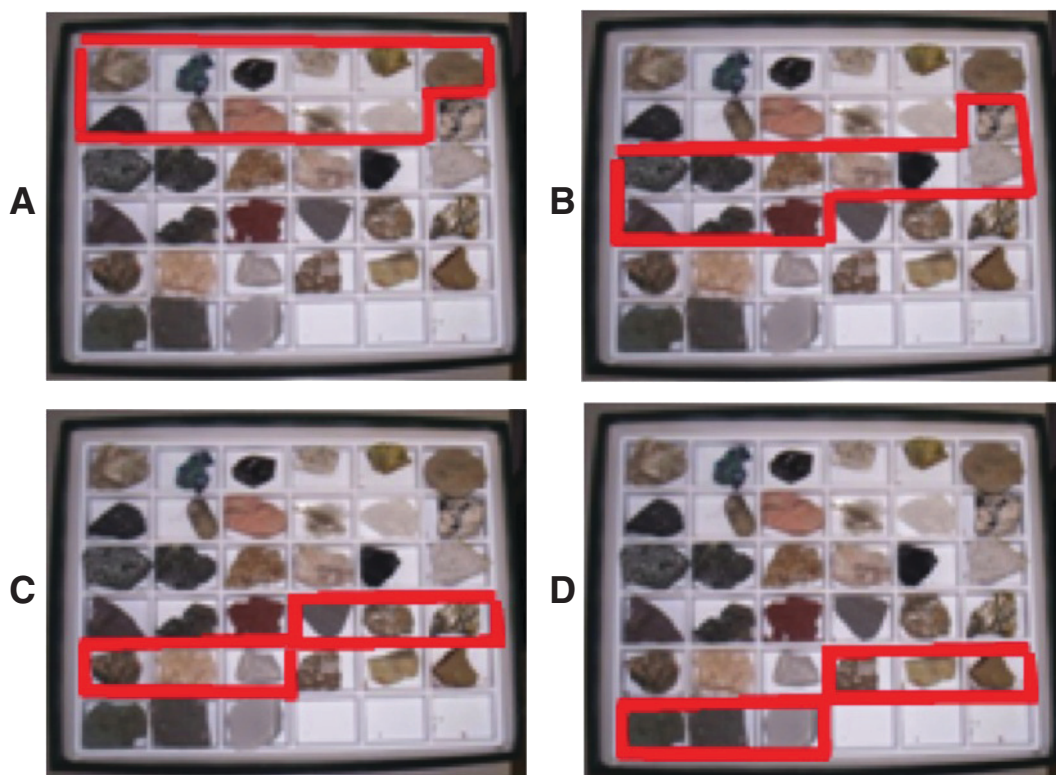
Distribution of Materials and Cost

Prior to the start of the term, students were contacted via email to verify, or in some cases obtain, their current addresses in order to send them materials via U.S. mail. This often required follow-up by telephone. In some cases, it was necessary to differentiate between their permanent mail addresses of record versus their current domicile at the time of the class. Two students expressed concern that because they were not currently located at their addresses of record, there would be a problem with taking the course. They were assured that their location was not important, but that they absolutely had to have the materials in hand for the course. Approximately half of the enrolled students were located within ULM's home Parish of Ouachita. Many students were in other areas of the state, three were out of state, and one was outside of the U.S. for a portion of the class.

Specimen kits were assembled from a combination of purchased materials and extant materials. This latter category included good-quality materials that were in archive storage. Using in-house materials reduced the total cost of the kits by nearly 50% of the cost of all-new materials. Each specimen kit, combined with the two required maps, equaled a per-student cost of $26.50 USD in 2007. Postal costs were approximately $6.00 USD. The university imposed a laboratory fee for this course of $50.00 USD.

Curriculum and Lab Exercises

Figure 3 shows the entry screen into the live Blackboard environment, including the navigation menu linking to lab exercises. Figure 4 shows the index page for "Lab Exercise 1, Identifying Minerals," in the Blackboard environment. In all exercises, students completed activities in the Blackboard environment that are labeled "Lab Activity," or, in some cases, "Worksheet." This work is equivalent to completing exercises in a hardcopy lab manual during the weekly meetings of a F2F lab class. For rock and mineral labs, students were to read through the web-page tutorial with their specimen kits in front of them. The Lab Activity sections are self-paced and intended to reinforce learning. They are scored by Blackboard; in some cases the correct answers are given, but in most cases not. Students repeated these activities to improve their performance. When they reached a level of performance (score) with which they were satisfied, they could move on to the graded (formal) quizzes. This process is analogous to a F2F format in which students would have their work inspected by an instructor, re-do incorrect sections in class, then take a quiz on the material either immediately or during the next lab meeting.

The list below includes all lab exercises in the order that students completed them. The live links refer to the complete tutorials for selected lab exercises, as well as informational materials. The complete list provides a contextual view of the curriculum, but live links are limited to those exercises that were particularly novel in their translation. Descriptions of the live links follow.[1]

- Welcome Letter
- Lab Exercise 1: Physical Properties of Minerals
- Lab Exercise 2: Economic Geology
- Lab Exercise 3: Rock Textures
- Lab Exercise 4: Igneous Rocks
- Lab Exercise 5: Metamorphic Rocks
- Lab Exercise 6: Sedimentary Rocks
- Lab Exercise 7: The Geologic Map
- Lab Exercise 8: The Topographic Map
- Lab Exercise 9: Introduction to Remote Sensing
- Optional Lab Exercise: Geologic Interpretation of Hellas Basin, Mars

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[1]Please click on the live links to view the supplemental files of selected exercises and informational materials.

Welcome Letter. This document is separate from the syllabus. The letter contains "straight talk" to the students regarding the instructional philosophy of cyberlearning, tips for success, and ensuring they have all the required materials. It also provides navigational aids and supports the standards outlined in the QualityMatters Rubric (Qualitymatters.org, 2008).

Lab Exercise 1. The purpose of this lab is not only to teach the specific physical properties of minerals, but also to train students to think critically about the scientific tasks of classification and categorization. The DVD video segments support this latter goal. Embedded at key places in the web page tutorial were prompts for students to stop reading and watch a particular video segment. (In the examples here, these prompts are live links to the video files in mp4 format.) In Lab 1, the activities are separated into a section for

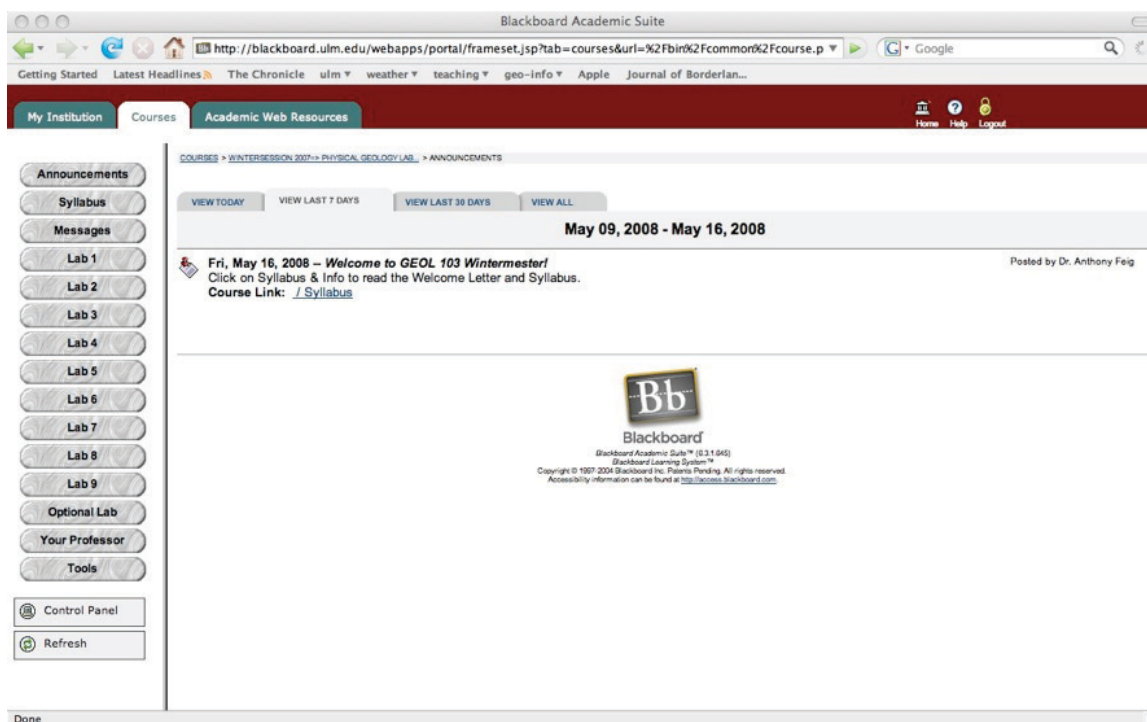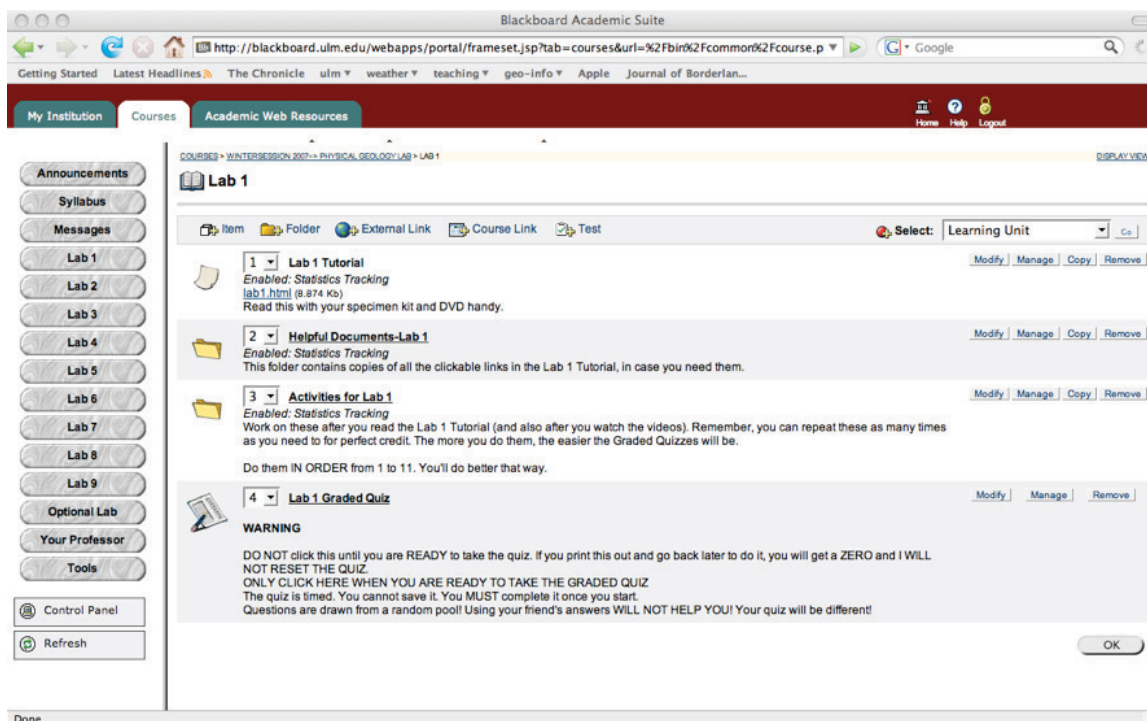**Figure 3. Screenshot of main entry screen. Navigation menu is to the left.**

Figure 4. Screenshot of the Lab Exercise 1 index page, "Identifying Minerals."

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each mineral specimen, as shown in Figure 5. Figure 6 shows selected questions that students answered for Specimen 1 (biotite) in this activity. Other rock and mineral labs follow this format.

Lab Exercise 3. Students are introduced to rock textures by mixing up their rock specimens and searching for common characteristics in a hands-on, constructivist approach.

Lab Exercise 7. The purpose of this exercise is to train students to extract meaningful information from a geologic map, and how to sort that complex information. The students take a virtual road trip starting and ending in Monroe, Louisiana, traveling along a circular route through the southeastern U.S. They note rock types and other geologic features along the way.

Lab Exercise 9. Remote sensing lends itself well to computerized instruction, because the materials are already digitized. Students install a freeware image viewer onto their computer that

Figure 5. Screenshot of the activities for Lab 1, broken down by specimen. Each link is a set of questions about each mineral specimen.
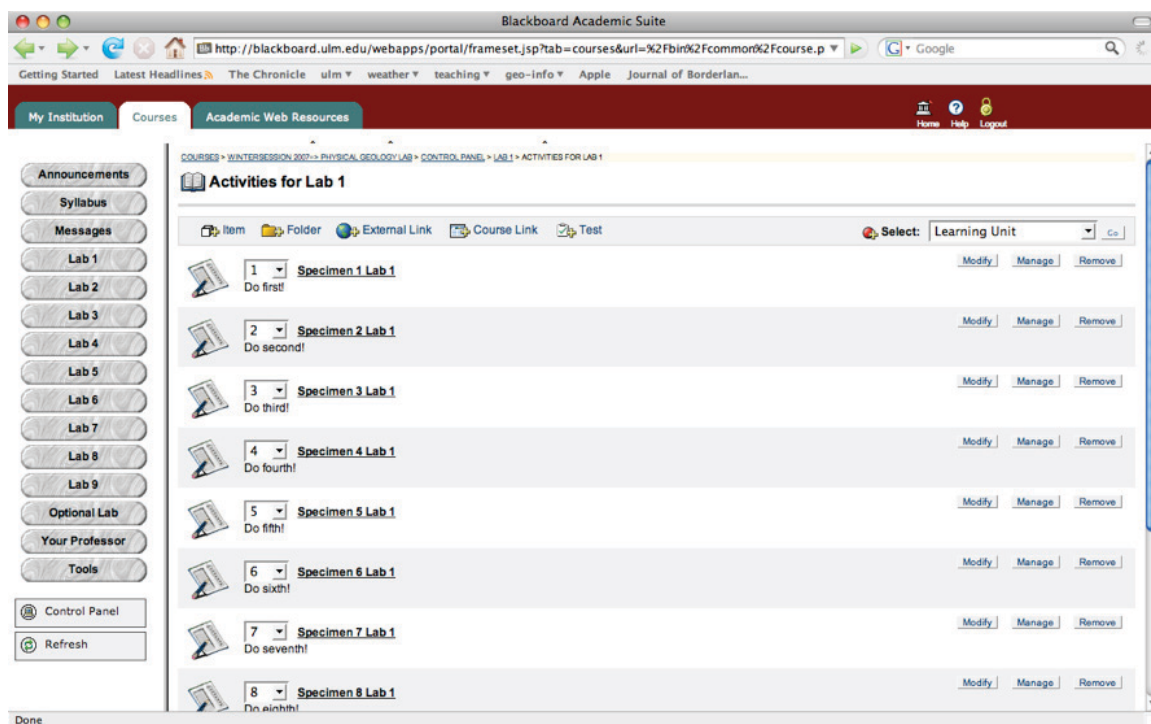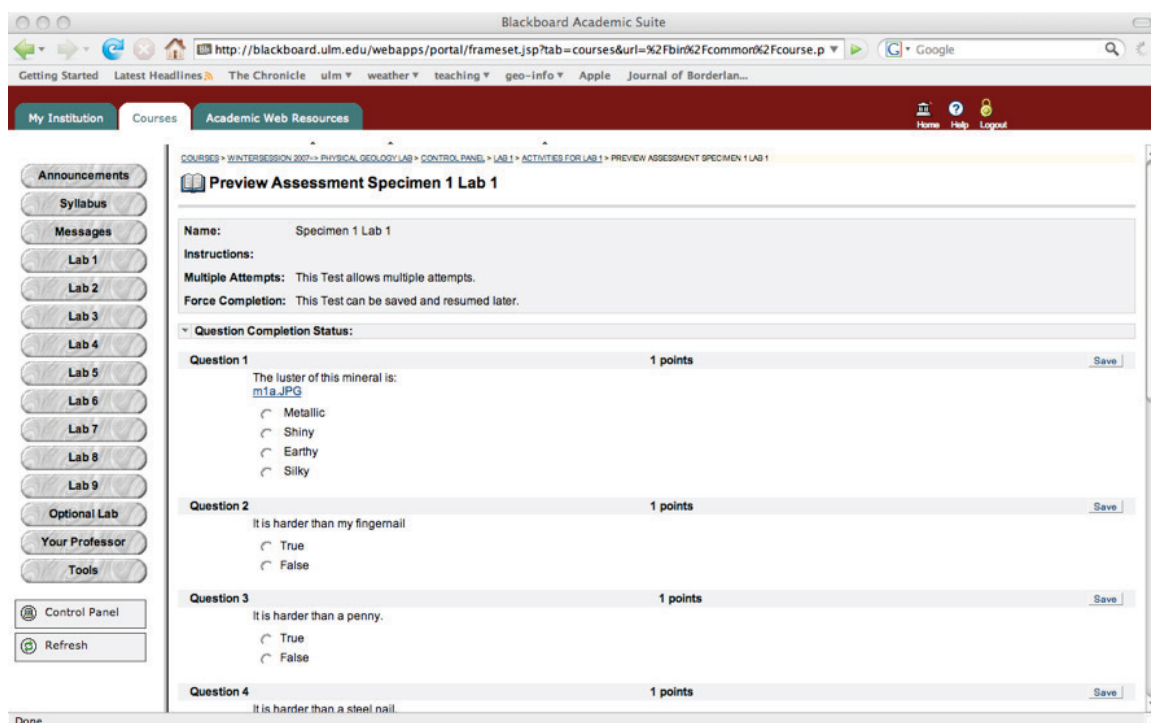

Figure 6. Screenshot of activity questions for Specimen 1 in Lab 1. The mineral for this activity is biotite.

is included on their CD-ROM and also available online (Erdas, 2007). The lab contains instructions on using the viewer, as well as how to manipulate light bands and interpret the images. This exercise did not exist prior to translation of the lab.

Assessment and Grading

Lab activities were designed to maximize time on-task and time spent with specimens, with less emphasis on high-stakes quizzing and testing. Students took graded quizzes only after satisfactory completion of the lab exercises. This is in accordance with the constructivist approach used in many physical geology laboratory courses (e.g, Feig, 2005; Grant and Benson, 1997). The point values for activities were the same as for quizzes. Unlike the activities, however, quizzes were timed and could not be previewed or repeated. When taking quizzes, students needed to have their specimen kits handy, as well as their notes on physical properties for reference. Again, the pedagogical emphasis is on observing, acquiring, and storing observations, rather than memorization.

The course Welcome Letter describes this philosophy in detail, so students could understand the pedagogical intent before starting the activities. Generally speaking, this approach tends to minimize occurrences of academic dishonesty, since students are informed that the focus is less on the correct answer and more on the correct process. To further discourage academic dishonesty during quizzes, questions are drawn from a pool that randomly selects specimen questions, and in cases of multiple-choice questions, the answers are scrambled for all iterations of the quiz. For example, students who sit down together in a campus computer lab will have different versions of the same quiz. Students receive instant feedback in the form of a raw score, but not the correct answers. Students who want to know which specific questions or specimens they did not answer correctly were required to contact their instructor directly. This approach not only prevented the circulation of "underground" quizzes, but also promoted individualized student-faculty contact.

In some lab activities, students were required to write short or long answers that were not graded by the course management software. Because the course was asynchronous, it was monitored and submissions were processed on a daily basis. Figure 7 shows a version of the graded quiz for the remote sensing lab exercise.

COURSE OBJECTIVES AND EXPECTED LEARNING OUTCOMES OF CYBERLEARNING AND F2F LABORATORY COURSES

Table 1 displays a matrix of course objectives, learning outcomes, student goals, assessments, and modes of delivery for the F2F

Figure 7. Screenshot of a randomly-generated version of the graded quiz for Lab Exercise 1, "Identifying Minerals."

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laboratory and the translated lab. This contribution is primarily concerned with the delivery and outcome of hand specimen activities. Therefore, only the objectives and learning outcomes relevant to those activities are presented in the table. However, delivery and outcomes of topographic and geologic map activities are included because their translation into the cyberlearning environment is likely to be of interest to geoscience educators. Additionally, a remote sensing exercise was created for the translated lab. Its objectives and learning outcomes are also presented. Table 1 also contains hyperlinks to complete quizzes. Quizzes were weighted such that they were not high-stakes testing events, but rather assessed reinforcement of learned processes. The quizzes focus less on a particular result, e.g., a mineral name. Lab activities were designed to meet specified learning outcomes, and the quizzes were intended to measure those outcomes via stated minimum student goals (Table 1). The quizzes are valid measures of outcomes and goals because of their focus on processes and how they were weighted.

For example, in the Mineral Identification Laboratory, the learning outcome was for students to "correctly use physical properties to distinguish and name mineral specimens" (Table 1). This learning outcome applied to cyberlearning and F2F sections. Using the mineral identification lab HTML tutorial and video segments, students observed physical properties such as hardness, cleavage, luster, and color. This process is analogous to the F2F "mini-lecture" where they are acquainted with physical properties. The cyberlearning students then access the "Lab Activity" in Blackboard. In the activity, they make observations of each mineral and compare their observations against a "key" that contains mineral names. This is analogous to the F2F activity of working through mineral specimens with a lab partner and recording observations. In a constructivist classroom, the students then compare their observations against a key with mineral names. When the cyberlearning students judge themselves ready, they take a timed quiz that presents mineral images and questions about the physical properties of displayed minerals. They refer to their original observations and their specimen kits, re-conducting their observations as necessary. This is analogous to the F2F process of taking a quiz either immediately after the lab exercise or at a subsequent class meeting.

In the Igneous Rocks lab exercise, students used the HTML tutorial to familiarize themselves with igneous textures. They distinguished between intrusive and extrusive

TABLE 1. OBJECTIVES, OUTCOMES, GOALS, DELIVERY AND ASSESSMENTS IN F2F AND CYBERLEARNING GEOLOGY LABS.

Course Objective	Learning Outcomes	Minimum Student Goals	Delivery		Assessment
			F2F	Cyberlearning	
Identify minerals	Correctly use physical properties to distinguish and name mineral specimens	75% of students will identify physical properties with a success rate of 75%; 75% of students will name mineral minerals with a success rate of 75%	Classroom instruction; Live demonstration; single, in-house specimen collection	Instruction via web tutorial; Demonstration via video segment; Individual student specimen collections	Formative self-assessments (labs); Criterion-referenced quiz
Identify rocks	Correctly identify textures and other properties to determine rock types (igneous, metamorphic, sedimentary) and name rocks	75% of students will identify rock types and name the specimens with a 75% success rate	Classroom instruction; Live demonstration; single, in-house specimen collection	Instruction via web tutorial; Individual student specimen collections	Formative self-assessments (labs); Criterion-referenced quiz
Explain rock formation in terms of plate tectonics	Observe textural differences in igneous and metamorphic rocks, and use those observations to speculate on tectonic settings of formation	75% of students will correctly place their rock specimen in the appropriate location on a cross-sectional view of a tectonic setting, with a 75% success rate.	Classroom instruction	Web tutorial instruction	Formative self-assessments (labs); Criterion-referenced quizzes
Understand topographic maps	Correctly determine elevation using contour lines; correctly calculate bearing and gradient along a line; correctly calculate vertical exaggeration of a profile	75% of students will pinpoint map locations, calculate distances gradients, bearings and vertical exaggerations with a 75% success rate	Classroom instruction; Live demonstration; in-house topographic maps	Web tutorial instruction; individual student maps	Formative self-assessments (labs); Criterion-referenced quizzes
Understand geologic maps	Correctly distinguish time periods and rock types on a geologic map; Correctly determine age relationships; Follow a predetermined highway route; Interpret a geologic cross section	75% of students will identify rock types, distinguish time periods and interpret a cross section with a 75% success rate	Classroom instruction; Live demonstration; in-house geologic maps	Web tutorial instruction; individual student maps	Formative self-assessments (labs); Criterion-referenced quiz
Understand basic concepts of remote sensing	Manipulate color bands to make inferences about a landscape; Determine elevation using shaded relief; Deduce land use patterns from satellite images	75% of students will identify land use, elevation and exposed surface composition using shaded relief and band manipulation with a success rate of 75%	n/a	Web tutorial instruction; freeware and LANDSAT images	Formative self-assessments (labs); Criterion-referenced quiz

Note: The 75% rubric for student goals was the institutional standard set by the University of Louisiana at Monroe in 2007. Hyperlinks refer to complete webarchive files containing quiz items for each objective/learning outcome/minimum student goals.

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rocks, as well as mafic and felsic rocks. Students then accessed the Lab Activity on Blackboard to use an identification chart containing a continuum of rock textures and percent of dark minerals to name each specimen. Similar processes were conducted for metamorphic and sedimentary rocks. Quizzes followed the same format, albeit timed, graded, and not repeatable.

COMPARISON OF STUDENT PERFORMANCE IN CYBERLEARNING AND F2F SECTIONS

The implementation of any translated course begs the question, "How does it compare to the F2F version?" A standard approach to this comparison is to establish control and experimental groups, provide for adequate controls, and compare learning outcomes statistically (e.g., Bernard et al., 2004; Smith and Dillon, 1999). Meaningful statistical comparisons are possible if the experimental and control courses utilized similar enough course objectives, assessment tools, and basic pedagogies, e.g., both instructors take a constructivist approach.

The cyberlearning lab section bore a very close resemblance to the F2F lab in terms of assessments, specimens, and pedagogical approach. Therefore, meaningful statistical comparisons are possible between the two environments. Of particular interest are comparisons focused on the rock and mineral labs, because (1) these represent the greatest challenge to translation; and (2) anecdotally speaking, geology educators are highly curious about and often suspicious of hand specimen study in the cyberlearning environment.

A pilot study was conducted to examine the outcomes of rock and mineral identification and classification activities. A cyberlearning section and a F2F section were statistically compared. The null hypothesis was that no differences existed between F2F and cyberlearning student performances on assessments in the rock and mineral lab exercises. The alternate hypothesis was non-directional; either group could have outperformed the other.

Method and Results

Five different statistical comparisons were conducted between groups, broken down by lab exercise: Minerals, Igneous Rocks, Metamorphic Rocks, Sedimentary Rocks, and an aggregate of these four labs. The control group was a F2F section that met once a week during a regular semester, completing one exercise per week. Because not every student attended every week, the *n* for this group varied between 18 and 21 participants. Absences were treated as zero scores and were included in the comparison runs. Rock and mineral labs in the control section took place during a consecutive, four-week period at the beginning of the semester.

The experimental group was a cyberlearning section that was scheduled during a four-week summer session. Not every student completed every lab, so the *n* for this group varied between 13 and 15. Uncompleted assessments received zero scores and were also included in the comparison runs. The control and experimental groups were assigned different instructors. The control group's instructor was not involved with the translation of the lab course. The total *n* of the combined populations varied between 31 and 37.

The data compared were the students' scores on quizzes, which are interval data. Because the alternate hypothesis was non-directional, a two-tailed (unpaired) Student's t-test was used to determine significant differences (Table 2). Statistical tests were conducted using Microsoft Excel for Mac 2008, version 12.2.3.

In all t-test runs $\alpha = 0.05$. All means, standard deviations, and standard errors of means (SEMs) are presented in Table 2. Degrees of freedom (df) in the five runs ranged from 34 to 37. In some cases, substantial differences in actual means are present. However, the standard deviations and SEMs show markedly less variability. The results of all t-tests were below critical t-values for all runs, indicating that no significant differences existed between groups in the individual lab exercises, as well as the aggregate. Therefore, the null hypothesis is not rejected. It should be noted that these

findings are specific to the conditions of this experiment, including the design of the F2F course, its implementation, and the sample population size.

Discussion: Implications and Future Research

F2F and cyberlearning environments each present specific challenges and advantages. In F2F environments, student attendance and engagement is a major challenge. Peer-to-peer learning and group work are the advantages of F2F settings. In cyberlearning environments, effective use of and access to technology present the major challenges. The self-paced, asynchronous environment and independence from the physical campus are key advantages of cyberlearning settings. The challenges of the different environments, although starkly different, are likely to be comparable in magnitude, if not equal in magnitude. Among some educators, the conventional wisdom likely exists that the F2F setting represents an idealized, baseline environment against which cyberlearning efficacy must measured. This wisdom should be considered cautiously. While it is true that the F2F setting is what educators are most familiar with, both environments present challenges, and the F2F environment is not perfect. Of course, both environments should be continually evaluated for effectiveness. However, cyberlearning should not be summarily dismissed as inferior.

The statistical results by themselves do not explain why differences did not occur between sections. This is an important question, ideally explored through qualitative inquiry. In 2007, ULM was in the process of establishing procedures for evaluating its cyberlearning classes. No protocols existed at that time for administering summative student evaluations of online courses to students who were off-campus. Therefore, it was not possible to triangulate quiz results (outcomes) with the results of student evaluations. Nevertheless, such comparisons may yield insight about factors such as the importance of in-person interaction to students, possible learning "curves" associated with technology, test

TABLE 2. STATISTICAL RESULTS OF QUIZ SCORE COMPARISONS BETWEEN THE F2F CONTROL GROUP AND THE EXPERIMENTAL CYBERLEARNING GROUP

Lab Quiz	N F2F	N Cyber	Means F2F	Means Cyber	SD F2F	SD Cyber	SEM F2F	SEM Cyber	t-Obtained	Sig.
Minerals	21	14	95.45	87.5	21.32	23.51	4.55	6.28	0.2481637	No
Igneous Rocks	19	14	69.84	85.71	28.18	29.8	6.46	7.96	0.06146	No
Metamorphic Rocks	16	14	76.25	81.43	38.79	27.7	9.7	7.4	0.7342581	No
Sedimentary Rocks	19	14	78.53	81.43	35.38	24.76	8.12	6.62	0.7358734	No
Aggregate	22	15	76.03	84.17	23.23	21.14	4.95	5.46	0.277579	No

Note: In all runs p=0.05; SD=standard deviation; SEM=standard error of mean. Sig.=Significance; "No" indicates that the t-Obtained value was below the critical value, and therefore the null hypothesis was not rejected.

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anxiety in different environments, and how the cyberlearning students actually used the materials. Finally, further statistical testing is warranted, utilizing more and larger control and experimental groups.

RECOMMENDATIONS FOR CYBERLEARNING LAB IMPLEMENTATION

Several recommendations can be made based on the implementation of the translated laboratory course. The recommendations are grouped into two categories. The first category is specific to instructors. The second category is specific to departments and institutions. Some of the institutional recommendations arise out of the ULM translation experience. However, others emerge either from the literature or from the accumulated wisdom and experience of multiple faculty in multiple institutions. Institutional level recommendations are included here to provide a holistic context for laboratory translation. A holistic perspective is particularly important for administrators who are considering large-scale cyberlearning efforts at their institutions.

Recommendations for Instructors

Understand the students. Instructors should have an understanding of whether potential/ enrolled students possess the necessary computer skills for the cyberlearning environment. Additionally, students must have computer and internet access in off-campus settings. Issues of the "digital divide" must be proactively addressed.

Conduct an in-person orientation session. An in-person orientation can be conducted on "syllabus day" as a way to ensure the students understand the course management software. In situations where meeting is not physically possible, the orientation could take place via a live web conference.

Consider easing into cyberlearning through hybridization. Instructors can build their comfort level by gradually moving into a cyberlearning environment. A hybrid course is a course that meets F2F less than 100% of the time. Some lab meetings can be replaced by electronic activities. For example, the week that an entire department goes to a professional society's annual meeting would be a good time to assign an electronic remote sensing lab.

Ensure the institution has an appropriate cyberinfrastructure. Instructors should determine if their institution is prepared for the increased bandwidth demands attendant to cyberlearning. The instructor must determine if current levels of campus technology support

are sufficient. Instructors must also determine if their institution has a standardized protocol for delivery of online content.

Recommendations for institutions

Understand the students. Cyberlearning holds broad appeal for students (Borgman et. al, 2008). This appeal can boost enrollments by appealing to student interest in technology-based education—and effective use of that technology. In some settings, the introductory lab is a gateway course into the geology major. Generally, students need the lab course before advancing to the next level of the curriculum. If staffing or space shortages occur, the lab requirement can create a bottleneck, which forces students to either wait to continue their sequence of geology courses or to choose a different major that has no bottlenecks. An online laboratory course addresses the bottleneck concern because it is less dependent on classroom space. Furthermore, an online lab can be offered during inter-sessions, and even in an asynchronous, open-entry/open exit four- or six-week format during regular semesters. Departments should consider whether a cyberlearning lab would appropriately address student interest, bottleneck issues, and provide flexibility for potential majors.

Have a clear vision of purpose. A translated lab should address an active, urgent issue. Space limitations and bottlenecks are two such issues, but others exist. For example, at many institutions, graduate teaching assistants instruct all introductory lab courses. Faculty and/or staff must manage multiple lab sections, tightly scheduled lab spaces, multiple graduate students and their highly variable schedules—all of which are exceedingly complex (Feig et al., 2003). If a department chooses to translate a number of its introductory lab classes into cyberlearning environments, the scheduling and management of teaching assistants may be reduced in complexity. Teaching loads for graduate students can be streamlined. For example, in a fifteen-week semester, a typical load for a PhD student is three F2F lab sections that meet once per week. An alternative load could consist of three online labs that take place in back-to-back, five-week sessions during the semester. In this case, the teaching assistant still has three sections, but they only teach one class at a time during each of the consecutive five-week sessions.

Cyberlearning must count toward regular teaching load. Translated courses do not run themselves. The work of preparing for an online course is distributed differently than a F2F course because it is frontloaded, but there is not *less* of it. Assigning translated courses to "overload" status (above the required amount of

classes to teach) may prevent faculty participation and buy-in.

Work together. A plan for cyberlearning should not be "sprung" on a group of faculty, either by their departmental peers or by external agents. A department's cyberlearning effort is strengthened by as many members as possible being stakeholders in the process.

Supplement, but do not replace. While cyberlearning environments can enhance a course's reach and impact, the course will likely suffer if it has no F2F or hybrid options. Additionally, not every faculty member will be willing or able to teach in a translated environment. Limiting a course to one environment potentially limits its impact.

Do not place a disproportionate responsibility for cyberlearning upon contingent faculty. Doing so may undermine broad faculty buy-in. This is especially true if the perception exists that online courses are assigned on the basis of job title. In many settings, contingent faculty are highly marginalized (Roueche et al., 1995). Physically disconnecting them from the department and the campus further marginalizes them, particularly if it appears that the regular faculty are "washing their hands" of cyberlearning. This issue will likely arise if cyberlearning courses are not counted as part of the regular teaching load.

Cost-cutting should not be the primary motivation for lab translation. Some institutions may be tempted to adopt a for-profit educational model of introductory geology curricula. However, it should not be assumed that online labs always have lower costs. Providing an adequate cyberinfrastructure (e.g., bandwidth) is not cost-free. Furthermore, quality control may be compromised if adequate oversight is not maintained. If an institution retains more contingent faculty and delegates online instruction to them, quality of instruction becomes more difficult to ensure, particularly with regard to at-risk, marginalized students. This is because the faculty themselves are marginalized. The monetary savings (if any) may be offset by other, intangible costs.

CONCLUSION

Cyberlearning presents opportunities and challenges to introductory geology curricula, particularly laboratories. With careful planning, an introductory physical geology lab can be translated to a cyberlearning environment. A translated lab has a number of practical applications, including addressing bottlenecks, reaching more students, and expanding the utilization of teaching assistants. This contribution is intended to provide one example of a translated

lab and a comparison of its outcomes, with regard to hand specimens, to its F2F component.

An introductory lab at the University of Louisiana at Monroe was translated and implemented in a cyberlearning environment. The translated course replicated the learning outcomes, assessments, and activities of F2F labs using a specimen kit and maps mailed to students, along with instructional video on DVD and web-based tutorials. No significant differences exist among measured learning outcomes between this course and an F2F course.

Translation and subsequent implementation of the cyberlearning lab ULM have led to recommendations for instructors and institutions. Faculty should have clear goals and should know their student populations. Institutions should count cyberlearning courses as regular load and should not "adjunctify" departments through a cost-cutting approach to cyberlearning translation. Administered with care and continually assessed, cyberlearning laboratories have the potential to complement and enrich geoscience education.

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