# Introductory Soils Online: An Effective Way to Get Online Students in the Field

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**ABSTRACT** Traditional soil science courses, especially with a hands-on lab component, have been face-to-face events. Several universities in the United States now offer a distance natural resources related degree, yet few have developed distance soils courses, arguably an essential part of a complete natural resource education. This article discusses the development of an introductory soils course with a hands-on lab to support natural resources and environmental sciences distance degree programs. In addition to reading the textbook and lecture notes, students complete labs that range from hand and mechanical texturing to analysis of soil nitrogen and carbon contents, often using household equipment. Qualitative observation from teaching both online and on-campus versions of the same course suggest that online students do as well, and sometimes better, than their on-campus peers. Using online learning techniques along with simplified hands-on labs may be very effective at conveying important concepts of soil science. In this way, students who have been excluded from a lab-based introductory soils course due to separation of classroom and place of residence now have access to a vital learning opportunity.

notes

People who have earned college degrees through traditional, on-campus courses are often suspicious of distance learning (Fowler, 2005). However, development of internet technologies has allowed for more interactive distance degree programs, resulting in very employable graduates. Moreover, even on-campus classroom instructors have increasingly used the tools of distance education (discussion boards, online quizzes, and assignments) to increase learning opportunities for on-campus students (Riffell and Sibley, 2004).

In the realm of science, including soils, many efforts have been made to develop web-based applications to enhance student comprehension and accommodate multiple learning styles. Eick and Burgholzer (2000) developed a web-based clay mineralogy tutorial to assist students learning clay structures and cation exchange capacity. Students have been able to run a spectrometer over the internet to analyze unknown chemicals (Scanlon et al., 2004). Stout and Lee (2004) designed a GIS and soil survey exercise to introduce students to GIS technology and the landuse information available in digital soil surveys. At the University of Florida, faculty have developed virtual field laboratories using 3-D imaging programs (Ramasundaram et al., 2004). A multi-university group of soil science educators has been developing components of an online soil education system (Mamo et al., 2006).

Most online soils courses do not attempt to include a laboratory component. Some courses do utilize web-based exercises that illustrate a concept through animation, but do not have a hands-on component. This is largely due to the difficulty of providing a soils lab that encompasses so many of the basic sciences—physics, biology, and chemistry. Web-based exercises are effective to a point, but hands-on approaches to learning in science can often be more successful. Taraban et al. (2004) demonstrated that students that handled live plant specimens were more successful identifying plant species than students solely using web resources. Soil science crosses many scientific boundaries and computer simulations can have serious shortcomings, especially if the student is expected to take field experience into a job after the course.

On campus, one of the most engaging parts of an introductory soils class is the lab. Physical contact with sand, silt, and clay brings to life the concept of soil particle size. Digging a hole or clearing off a road cut to observe layers of color, structure, and texture in a soil takes soil from a two-dimensional concept to a three-dimensional reality. Can this experience be provided without a lab instructor for an online course? And can it really be effective?

## Soils and Natural Resources

Oregon State University (OSU) developed an online natural resources (NR) degree program in 2000. Enrollment in the NR program has been steadily increasing since its inception. From the perspective of a natural resource professional and a soil scientist, one of the peculiarities of the program is that it did not have a required soils course. The need for such courses is great, even if only to bring awareness of what soil is and its role in life cycles and natural

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Abbreviations: BC, baccalaureate core; NR, natural resources; OSU Oregon State University.

**Table 1.** Academic requirements for baccalaureate core science courses at Oregon State University.

| | |
|---|---|
| 1 | Four credit lower division lecture and laboratory course |
| 2 | Emphasize elements of critical thinking |
| 3 | Focus on the meaning of the fundamental concepts and theories that broadly characterize basic (rather than applied) physical or biological science |
| 4 | Illustrate, demonstrate, and analyze natural phenomena and systems |
| 5 | Provide historical perspectives and context on the evolution of major theories and ideas |
| 6 | Demonstrate interrelationships or connections with other subject areas |
| 7 | Examine the nature, value, and limitations of scientific methods and the interaction of science with society |

resource sustainability (Weil, 2002; International Union of Soil Sciences, 2006; Hopmans, 2007).

A survey of academic programs nationwide in 2003 indicated that no university offered an online lab-based soils course without a required on-campus visit for the lab component. Indeed, OSU had an online lab-based course that required a week-long campus visit to complete the lab portion of the course. This course was titled Soils: Sustainable Ecosystems.

Soils: Sustainable Ecosystems is a lower division (200 level) baccalaureate core (BC) course at OSU, meaning it will satisfy a physical or biological science requirement for all undergraduates. Available on-campus, BC science courses include introductory chemistry, physics, biology, and geology, to name a few and must meet specific educational goals and requirements, including a laboratory component (Table 1). The multidisciplinary nature of soil science lends itself well to meeting these broad BC goals.

A lab-based soils course for nonmajors can be a challenging course to develop. Soil science covers a range of science topics including biology, chemistry, and physics. Students enrolled in such a course can range from chemical engineering majors to political science majors and their experience in science may be limited to only that covered in college prep courses in high school or none at all.

In spring of 2004, a fully online version of Soils: Sustainable Ecosystems was offered for the first time. The purpose of this article is to describe the course and its laboratory components developed for the online version and discuss their potential effectiveness in soil science concepts and principles via lab and field skills to a distance student. Feedback from readers is welcome. Currently, a study is underway to compare on-campus and online student learning in this course. An educational study is underway to compare the effectiveness of the online version of the course to an on-campus version.

# The Course

The learning outcomes or goals designed for the course are:

- Investigate the principles of soil science as they relate to your everyday experience.
- Gain an understanding of the morphological, physical, and biological properties and processes in soils.
- Appreciate the importance of soils as a natural resource and their role in ecosystems.
- Provide a foundation for a life-long learning experience in soil science and natural resources.

Additionally, this course is designed to meet the OSU BC requirements (Table 1). Therefore, the course is designed for nonsoils majors and is not meant to substitute for a rigorous introductory soils course. The OSU catalog course description for the course is:

> Soil ecosystems as a medium for plant and crop growth, the cycling of nutrients, supply and purification of water, and a habitat for a diverse population of soil organisms. Relationship of human activities to the sustainability of soil ecosystems.

The catalog description for the soils major introductory course (300 level) is:

> Origin, formation, classification, physical, chemical, and biological characteristics; ecosystem functions of soils; effects of soil management on agricultural and forest crop production.

The soil major course requires two quarters of chemistry while the nonmajors course has no chemistry prerequisite.

Once the effectiveness of the course is evaluated, it may be possible to explore how to design an effective online introductory soils course suitable for soil science majors that would be transferable to other institutions as a true introductory soils course. Ideally, the current online course could articulate to other institutions as a lab-based exploratory earth sciences course that would meet general education requirements.

## Course Structure

The required materials for the student are the textbook, supplemental notes and figures, and a lab kit. The initial textbook was *Soils* by Dubbin (2002); however, recent terms have used an alternate text due to low supply of the Dubbin book. Supplemental notes and figures are available online in PDF or HTML format.

Learning activities during the course include three required group discussion boards, two online quizzes, and seven laboratory assignments. Demonstration of competency is via a midterm, final exam, and a comprehensive lab report.

The course is 10 weeks in length (quarter system) and delivery is via the Blackboard system. Each week a new topic is introduced (Table 2) as well as a lab assigned (Tables 2 and 3). Labs are due via the course webpage by the end of the following week. Quizzes and exams are made available from Thursday to Sunday. Quizzes and exams have a time limit, must be completed once started, and access to the answers is restricted until after the assessment period is over—this is to encourage material review before the quiz or exam and also to discourage dishonesty.

## Required Discussion Boards

Discussion topics are posted on Wednesday and are open for input through Sunday. Students are required to submit

**Table 2.** Weekly topic, laboratory subject, and assignment for CSS 205, Soils: Sustainable Ecosystems.

| Week | Topic | Laboratory exercise | Assignment |
|---|---|---|---|
| 1 | overview of soils | soil collection/chemistry review | student introductions discussion |
| 2 | minerals and physical properties | rocks and minerals | discussion 1 |
| 3 | organic matter and soil profiles | soil color | quiz 1 |
| 4 | soil water and chemistry | particle size | review discussion |
| 5 | soil fertility | bulk density and soil water | midterm exam |
| 6 | biology | | |
| 7 | soil erosion | ph and fertility | discussion 2 |
| 8 | soil classification | soil surveys and soil descriptions | |
| 9 | soil survey | | quiz 2; final report mailed |
| 10 | global soil issues | | discussion 3; final exam |
| Finals week | | final exam | |

**Table 3.** Laboratory topics and objectives for each lab.

| Laboratory exercise | Lab objective |
|---|---|
| Soil collection/chemistry review | 1. familiarity with and ability to describe landscape types |
| | 2. proficiency with acquiring geographic information via the internet |
| | 3. ability to collect and prepare soil samples |
| | 4. familiarity with properties of common soil elements (e.g., iron) |
| Rocks and minerals | 1. familiarity with common soil forming rocks and minerals |
| | 2. estimate inherited soil properties from parent material mineralogy (e.g., pH, texture) |
| Soil color | 1. understand the primary soil pigmenting agents |
| | 2. associate soil color with soil characteristics (e.g., degree of weathering, drainage) |
| | 3. develop land-use interpretations from given scenarios |
| Particle size | 1. develop rudimentary hand soil texturing skill |
| | 2. familiarity with soil texture classes and the texture triangle |
| | 3. predict impact of soil texture on soil processes |
| | 4. relate settling rate with particle distribution in hydrologic systems |
| Bulk density and soil water | 1. calculate bulk density for a given volume and mass |
| | 2. approximate bulk density using a simple field method |
| | 3. calculate pore space and water content for field samples |
| | 4. understand the relationship between density, pore space, and water content |
| | 5. predict the impacts of land use on these properties and land use capability |
| pH and fertility | 1. understand the relationship between soil development, climate, and soil pH |
| | 2. predict soil pH based on parent materials, geology, and landscape |
| | 3. know the micro and macro nutrients |
| | 4. use colometric tests to measure soil pH and status of N, P, and K |
| | 5. relate the concept of fertility to a region for agricultural and native vegetation systems |
| Soil surveys and soil descriptions | 1. be able to explore online soil database for information for a given location |
| | 2. use web soil survey (USDA–NRCS, 2006) to investigate soil characteristics for a location |
| | 3. delineate and describe horizons and soilscape characteristics for a local soil profile |

at least one original thread regarding the discussion topic and must post at least one response to original threads of two other students. Discussion participation is weighted on several criteria, including timeliness of posting (e.g., posting over several days vs. posting all three at 11 pm Sunday night), number of follow-up posts above the three required posts, and the quality of the post (e.g., a post that states "I agree" does not have high quality).

## Laboratory

It is impossible to replicate a fully furnished soils laboratory for every online student. One goal of the online lab development was to convey the general theories and principles of the activities rather than to stress quantitative measurements and assessment. The rationale for this is the realization that few if any of these nonmajors will be working in a soils lab upon the completion of their degree. This approach also fulfills BC requirement 3 (Table 1). The important take home message is: what lesson does the lab assignment teach and how can it be applied to the student's interaction with natural resources on a daily basis. For example, it is unlikely that a student will be doing hand textures as a chemical engineer; but driving along a muddy river, they will understand that the water has suspended sediments and that the sediments will settle out based on particle size and water flow. Perhaps they will someday utilize this knowledge as they investigate building their dream home.

To this end, the laboratory kit provides some simple components that might not be accessible to the student (Table 4). In addition to the lab kit, the student is responsible for assembling a group of common materials that they have at their disposal or can easily acquire (Table 4). The lab kit typically costs students about $20 including shipping.

Each laboratory exercise has a lesson objective (Table 3), a discussion of the lab topic, an explanation of why it is pertinent to studying soils, and relationships with other natural resources. The purpose of detailing this information is because there is no face-to-face contact with the online student. In an on-campus setting, the instructor freely provides this type of supplementary information verbally. That luxury is not available online, so detailed information is provided as text with the lab. Because the instructor is not present, the instructions in the lab are fairly detailed and may seem excessive at first glance. However, the experience of several terms has shown that too much information is not really possible. Again, in an on-campus lab, the instructor can tweak or refine lab instructions verbally but the online lab must be clearly laid out to avoid serious confusion.

Labs are due 2 weeks after posting and students get an initial grade solely on completion of the lab, not the correctness of their answers. Once the due date has passed, credit for the lab is no longer available. After labs are received, a completed, correct lab is posted to the website for students to independently review their work. The final lab report at the end of the term must have the student's original work along with any corrections that are necessary. In this way,



**Table 4.** Contents of course laboratory kit and common supplies provided by the student.

| Item | Lab use | Purpose |
|---|---|---|
| Lab kit | | |
| 250-mL graduated cylinder | bulk density | accurate water measurement for bulk density exercise |
| Calgon | soil texture | contains sodium hexametaphosphate for clay dispersion in texture exercise |
| pH colorimetric | pH | determination of soil pH |
| N, P, K colorimetric tests | fertility | determining N, P, K in soil samples |
| Color pages | color | provides color references for some common soil colors (not the full Munsell range) |
| Student | | |
| Ruler (metric) | soil texture, bulk density | determine texture ribbon length and hole dimensions for volumetric calculations |
| Three 1-quart jars | soil texture | contains soil suspension to demonstrate settling rates |
| Scale | bulk density, soil moisture | obtain moist and dry soil mass. Scales availability suggestions included grocery stores and post offices |
| Soil | soil collection, color, texture, pH, fertility | the soil is collected in the fist lab and used for several experiments |
| Shovel | soil collection, soil description | used to collect soil samples and for digging soil pit or clearing road cut for the last lab |
| Plastic wrap | bulk density | lining hole for bulk density experiment |
| Camera | all active labs | Students must provide photo documentation of their lab work. Photos are included in the final lab report |
| Bottle water | pH, fertility | filtered, additive free water is used to approximate distilled or deionized water for chemistry-related labs |

the students are getting feedback on their work but are allowed to adjust it based on instructor input before it is assessed for correctness. This somewhat mitigates the lack of face-to-face interaction in the laboratory.

*Lab Overview*

The overarching goal of the online lab component is to have students interact with the principles and components of soil science, and see how soils influence the landscapes they live in, the products they consume, and essentially their everyday life. Each lab has a set of objectives (Table 3) and exercises, hands-on and web-based, that are designed to meet the objectives.

Laboratory topics and objectives are laid out in Table 3; however, they do not provide a clear insight into the degree of activity required. A few examples of the lab may help illustrate the hands-on nature of the labs.

**Lab 1: Soil Collection/Chemistry Review.**

*Soil Collection*. The student is required to select three landscape locations in their area that represent (i) a riparian area, (ii) agricultural or turf area, and (iii) a wetland or ponded area. The reasoning given to the students is that these three locations have different land uses and geomorphology, which will likely influence texture type, organic matter, and chemistry. After getting access permission, students collect enough soil to fill a gallon baggie and photograph the site and the hole. Emphasis is placed on accurately describing the location of the sample and the date of collection. Online tools such as Topozone.com and Google Maps (maps.google.com) are used by the students to provide a geographic reference. This also allows the instructor investigate the locale and to provide feedback about the specific area.

The samples are air-dried and coarse material, such as roots and rocks, are picked out. Students are encouraged to use a colander or coarse screen to sieve the soil. Notes are made about root and rock content and included in the report. The lab report includes geographic coordinates for the sites (obtained from online mapping programs), and a general description of the sites and soils that includes vegetation, climate, and land use. The astute students also investigate site area history and geology. Photos are taken for each soil pit and landscape for inclusion in the comprehensive final report.

The first lab for the on-campus version of this course covers landscapes, including observations about vegetation associations, climate, geomorphology, landuse, and soils. Students turn in a summary set of notes and illustrations on the sites visited. In this regard, both courses have a similar experience. On-campus, there are typically some students who drag their feet, do not participate, and distract the larger group. Online, students must participate because they are the sole person responsible for their lab. There can be no foot dragging if they want credit for the lab. What they do miss, in comparison to the instructor-led field trip, is a discussion about what they are seeing and the ability to question what they are observing. However, they can (and do) converse with the instructor via email and discussion board about what they experienced.

*Chemistry Review*. Both online and on-campus students complete this exercise. Students are supplied with a periodic table that is blank except for atomic numbers in the boxes. They are directed to several websites that have information on the elements and required to provide element name, atomic mass, group, oxidation numbers, abundance in the Earth's crust and atmosphere (parts per million), and summary of uses for the element. Elements reviewed are H, C, N, O, Na, Mg, Si, P, S, Cl, K, Ca, Mn, Fe, Zn, and Pb.

Some upper division students with some science view this lab as busy work. It is designed largely for the nonmajors or students with a limited chemistry background in order to provide context for future lectures and labs. For most students it is an essential review and is referred to constantly throughout the course in lecture and lab.

**Lab 4: Particle Size.** The lab intent is to help students differentiate between the three soil particle sizes—sand, silt, and clay—and gain perspective on the properties and influences of these particle types on soil processes and development. The two components of this lab exercise are hand texturing and particle settling (mechanical) analysis. Students utilize their samples from Lab 1.

The hand texturing utilizes the flow chart developed by Thien (1979) that relates soil cohesiveness and ribbon length to texture class. Students are required to hand-texture each soil three times and use the average ribbon length to place the soil in a texture class. The emphasis is on correctly placing the soil in the loam, clay loam, or clay category, with sandy or silty modifiers being secondary. Two video clips of the instructor hand texturing are posted on the website, one being a loam texture and one a clay texture so that students have a better idea of the method than just a picture or flowchart provides. Photo documentation of all three samples is required in the final lab report.

Critical to this exercise is association of the student's results with a soil texture class located on the textural triangle. Students must provide an estimate of percentage sand, silt, and clay after going through the hand-texture exercise. This forces them to see the relationship between the texture class they have determined and the other classes, in addition to them learning to use the triangle.

In the mechanical analysis, three quart jars are one-fourth filled with each of the three soil samples. Dry settling is accomplished by gently tapping the glass, but not packing the soil. Water is added to the soil until the soil is saturated. Students measure the dry height and wet height and discuss any changes that occur. In the topic discussion, the concepts of flocculation and dispersion are introduced. Sodium hexametaphosphate (via Calgon) is added to aid in clay dispersal, water added to fill the jar to three-fourths full, and shaken vigorously for 5 minutes. Students make observations on settling depths and times and relate these to soil particle size and Stokes' Law on terminal velocity. Ideally, the depths of the soil, measured at appropriate time intervals (based on Stokes' Law) could be used to determine texture class. However, without complete settling of clay and also without removal of organic matter, results for any soil other than sandy loam are dubious. The method is qualitative and the intent is for the students to visualize the separation of particle sizes based on settling rates. They do compare their hand texture results to the mechanical

**Table 5.** Comments from students in Soils: Sustainable Ecosystems with regard to the class as a whole (comments are copied as is, no corrections made for spelling and grammar).

| | |
|---|---|
| 1 | Well, I have to admit that before this class I never really thought about soil before. I only garden a little and I am not much for playing in the dirt. However, after this class I have found that soil is more interesting and I am going to be thinking about it a little more than I used to. |
| 2 | My kids are "dirt" experts. I've included them in every lab we did in this course (they are 13 and 17). We just spent 4 days in the high Colorado back country. They pointed out many examples of what we did in labs. We spent extra time discussing what was happening to soils. It was great! |
| 3 | It makes me stop and think about what processes have actually occurred to mold the earth to its current shape. So many things are taking place…and I never before would of believed it could be this vast. |
| 4 | Isn't it wonderful when you experience something that is an eye opener! It gave a new perspective on things. I now see soils and try to guess what order it is or if I happen to see a profile I would try to pay attention to see how many horizons does it have. |
| 5 | I have done an awful lot of traveling over the last week, moving from Oregon to Montana, and have found my eyes straying to the side of the road, observing the changes in soil and landscape. |
| 6 | On a final note, I am also glad that now I have a better understanding of the different soil properties and processes. So many factors I've learned, affecting different soils around the globe. Awesome! |
| 7 | I have always known that soils were important but I guess I really never considered just how closely soils are tied with so many functions and processes of the earth. |
| 8 | I have to admit to not realizing there was so much in soil (as opposed to dirt!). This class has inspired me to learn more about soil science. |
| 9 | You can't get any more hands on (and hands dirty) than this. The discussion board made it feel more like a classroom setting also. |



separation results, but are informed that clay will always be underestimated in the mechanical analysis.

These labs, as well as the remaining labs, give the students visual affirmation of the concepts covered in the lecture and textbook. They also serve to meet the lab educational objectives (Table 3). They are exercising math skills when computing bulk density and water content in Lab 5. Because Lab 5 requires them to go and find a compacted trail and noncompacted site, they are also looking at real-world examples of human impacts on soil quality and ecosystem processes. They learn (or relearn) that water is a noncompressible fluid and that 1 mL water occupies 1 $cm^3$. Each lab has a set of questions that require the student to synthesize the lessons from the lab experiment to problem solve or interpret site conditions for real-world examples.

## Student Demographics and Reactions

The course Soils: Sustainable Ecosystems (CSS 205) has been offered for six terms thus far. More than 150 students have completed the course, roughly 65% female and 35% male. Although the majority of students enrolled in the course are natural resources majors (~45%), other majors include environmental science, agriculture, post-baccalaureate, liberal studies, human development, business administration, psychology, and forest engineering. A majority of the students are in the Pacific Northwest, but more than 20 states have been represented. Students have also been located in St. Thomas, Indonesia, Saudi Arabia, and Portugal.

An intriguing trend has been the presence of traditional on-campus students enrolling in the online courses. On-campus classes have limitations for many active students due to scheduling conflicts and course availability, and an increasing number of on-campus students enroll in online classes.

Oregon State University requires instructors to provide students with the opportunity to assess the courses they take. In an on-campus class these evaluations are typically given during a regularly scheduled class and at a minimum, most students complete the Scantron portion of the evaluation. Online courses are also subject to student evaluations; however, it is the student who must go to the online assessment and returns are not as high in an on-campus course. Approximately half of the online students have completed the evaluations. The main applicable question is "The course, as a whole, was:" with the ranking answers being very poor (1), poor (2), fair (3), good (4), very good (5), and excellent (6). During the six terms, the average ranking is 4.9, very good.

In addition to the required discussions, the students are invited to post comments about the course, anonymously if they desire. For students who are completing a degree online, many of them take courses entirely in front of a computer or a textbook. This course has required them to leave the house, and go out and experience one aspect of natural resources in person. A sampling of their comments indicates how studying soil has broadened their perspective on natural processes around them (Table 5).

Fig. 1. Online student Matt Beaulaurier, an Oregon State University forest engineering student, next to his soil pit from Lab 7. The soil is mapped as a member of the Jury series, Typic Udivitrands.

## Discussion

What I find unique and powerful about distance education is that there are no geographic boundaries in an online course. Being at a distance has its advantages:

- Classmates around the world expose each other to different environments (e.g. a student in Oregon and a student in Indonesia share environmental perspectives).
- Discussion board threads include both traditional students and students who have years of professional natural resources experience.
- Opportunities exist to hear first-hand about soil landscapes that cover all 12 United States Soil Orders.
- Hands-on experience is required—no chance to hide in a lab group and not get dirty (Fig. 1).
- Perspectives of students in multiple majors are shared—more than 25% of CSS 205 students are nonagriculture/natural resources majors.

This course was developed to allow online students to experience a hands-on soils lab that included field experiences without having to attend an on-campus lab section. Using a simple, inexpensive lab kit and common household goods, the students can approximate many of the lab exercises that take place in an on-campus soil science course.

Anyone who has taught an on-campus laboratory course will have the intimate knowledge that not all students participate equally in lab experiments, especially when labs are group-based. An effective teacher can develop lessons that require participation from all students; however, this is often the exception rather than the rule. In the online class design, all students must complete all the labs. This is a distinct positive difference for the online class.

Not all discussion board topics in the course have required participation. Discussion board topics are opened for exam preparation where topics are reviewed and questions posted and answered, either by fellow classmates or the instructor. A discussion board is also created for each laboratory assignment to help students who are having difficulty with performing a lab or if a serious error in methodology becomes apparent as the students attempt the experiment. In the first offering, this troubleshooting was helpful in the nitrogen experiment when no student observed a reaction in the nitrogen strips. The range of strips for this term was 0 to 500 ppm nitrate. These were not sensitive enough for soils work. The experiment was adapted to include the pulverized plant test, which had recordable amounts of nitrogen and future terms used more sensitive test strips. The discussion boards have an additional benefit when the instructor is a reader and contributor.

## Closing Thoughts

Many challenges arise when offering an online course. Instructor assessment of student achievement is one of the most critical (Lorenzetti, 2005). I have been a program advisor for online and on-campus programs, as well as instructor for both, and have found, both through experience and student feedback, that instructor involvement is key to student attitude and success. Much like a lecture hall class, an online instructor who is detached from the students will put students to sleep and create subject apathy. Teaching online takes time and energy. So does teaching in a classroom.

A quantitative study on the effectiveness of online lab-based soils courses is needed and currently underway. But until then, my experience as both an on-campus and online instructor for soils is that online students perform as good, if not better, than their on-campus cohorts. And as advisor for some of these same online students, I have seen them take this success into real, in-the-field careers and be successful there.

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