WINTER 2016 • Volume 37, Number 2

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CUR Focus

Partnering with State Enriches Environmental Research for First-year Students

Abstract

Introduction to Environmental Sciences (ENVI 110) and its lab, Environmental Sciences: Human and Environmental Change Laboratory (ENVI 110L), offer large numbers of first- and second-year students a significant and meaningful research experience at Indiana State University. All students are required to complete at least one science course with a lab, and ENVI 110/110L is one of only four ISU-approved courses. Thus a high percentage of students taking these courses and benefiting from the research opportunity offered are not science majors. The lab includes a field day at Indiana's newest fish and wildlife area, known as the Wabashiki (a Native American name for the Wabash River). The goal of the experience is for each student to collect at least two soil samples, take GPS coordinates of each soil sample, determine soil color, texture, and pH, and use that data to test a hypothesis of their own making. After careful checking of the students' soil samples, those deemed complete and valid are compiled and the results reported every semester to the Indiana Department of Natural Resources to help officials track the environmental status of the area. Surveys of students suggest high levels of satisfaction with the experience.

Keywords: *hypothesis development and testing, field trip, environmental science, first-year students, undergraduate research*

The Introduction to Environmental Sciences course (ENVI 110) and its lab, Environmental Sciences: Human and Environmental Change Laboratory (ENVI 110L), annually offer 700 to 800 mostly first- and second-year Indiana State University (ISU) students a significant and meaningful research experience. The university's Foundational Studies Curriculum requires every student to complete at least one science course with a lab, and the environmental science course and lab (hereafter ENVI 110/L) is one of only four approved ISU courses. Thus most students in the course are not science majors, and so the lab offers an opportunity to expose many nonscience majors to a research/fieldwork experience.

We will discuss the history of ISU's Foundational Studies curriculum; students' process of hypothesis development, field testing, and the field day; how collected soil samples are used by others; students' assessment of the research experience; and how other faculty could integrate a similar field experience and research project into their large first-year courses.

Introductory Environmental Sciences in the Curriculum

The introductory environmental science course and lab (ENVI 110/L) has been evolving over eight years. It emerged during a stressful time in the then-Department of Geography, Geology and Anthropology. Three separate programs were deciding whether to go their separate ways or seek a common identity. After one unsuccessful attempt at proposing the course and lab and after the department decided to seek a common identity as Earth and Environmental Sciences (EES), ENVI110/L was first taught online in summer 2009 and on campus in fall 2009. Initially the lab did not include the field experience.

Simultaneously, broader institutional changes were underway that contributed to an emphasis on a meaningful hands-on experience in the introductory environmental science course and lab. In 2009 Indiana State University launched its current strategic plan, "Pathway to Success." Goal Two is to "advance experiential learning so that all ISU students have a significant experiential learning experience within their major" (Indiana State University 2009). Goal Three is to "enhance community engagement to foster the engagement of students, faculty, and staff in the life of our communities and in pursuits improving their economic and social well-being" (Indiana State University 2009).

Two initiatives from Goal Two—"apply the science of learning to the learning of science" (referring to the NSF Science Education for New Civic Engagements and Responsibilities program) and creation of the Center for Student Research and Creativity—joined another strategic-plan initiative, creation of the Institute for Community Sustainability, to create a new climate on campus. These changes, plus the new identity of the department, have led to different hiring decisions—new faculty hiring has focused on interdisciplinary researchers working in the nexus between the physical and social sciences. All of this has combined to support and contribute to the continued evolution of ENVI 110/L into its current form, with 700 to 800 students annually participating in a field day at the Wabashiki Fish and Wildlife Area just outside Terre Haute, Indiana (http://www.in.gov/dnr/fishwild/6188.htm).

Because our introductory environmental course and lab served as both a general-education lab science course and as the gateway to the newly named department, the existing published lab manuals were no longer appropriate. A self-published lab manual was created for 110L, which is now published by Hayden-McNeil (Latimer 2016). The goal is to provide a hands-on experience that touches on many of the major concepts covered in introductory environmental science regardless of who is teaching the course—water quality, erosion, soil chemistry, environmental health, extinction, scientific method, atmospheric processes, climate change, etc. The topics are arranged so that students can see how the samples they collect fit into the bigger picture.

Before 2009, ISU and the Department of Earth and Environmental Sciences, in particular, began to embrace the program called Science Education for New Civic Engagements and Responsibilities (SENCER), which is an NSF-funded program to make STEM (science, technology, engineering, and mathematics) education more meaningful by shaping students' learning around important civic issues. Two of this article's authors, Latimer and Speer, met and discussed integrating a field trip to the Wabashiki area into the introductory environmental course. Thereafter, the lecture and lab became more hands-on through use of real-world research projects.

The goal of the field trip—which began as an all-day Saturday experience and was later reduced to two half-day experiences as enrollment in the course grew—was not to collect samples but to expose students to a wetland field experience. But it continued to evolve into complete and meaningful research. In fall 2010 students gathered the first samples of soil nutrients. There were insufficient resources to process the soil samples for analysis by the department, and thus the students collected data but could not analyze it.

Spring 2012 marked the last of the all-day Saturday field trips, as the logistics of the field trip became too difficult due to surging enrollments. The department and the two new campus centers described above all contributed funds to purchase a portable XRF (x-ray fluorescence spectrometer) so that the soil samples could be analyzed accurately and economically, providing up to 800 students each academic year with a research experience proceeding from hypothesis formation to data collection, to analysis, and drawing of conclusions. In fall 2013 the field day became an "in-class" field trip for 110L, and it has remained so. To prepare the students for the class fieldwork, the laboratory curriculum was rearranged to offer skill-building activities building up to the research project.

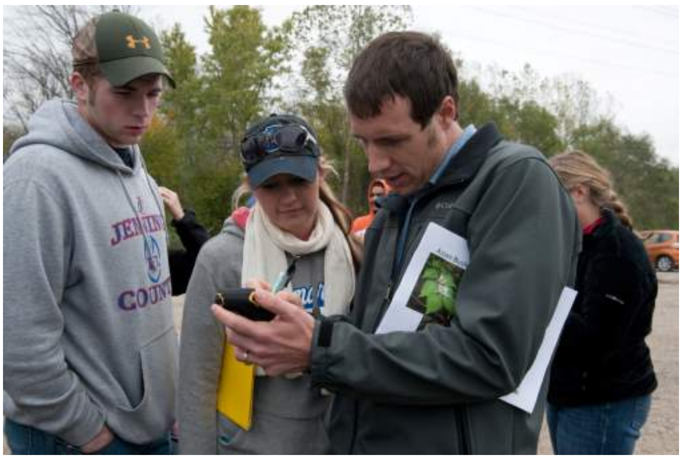
There are challenges. The timing of the fall field trip is complicated because the Indiana Department of Natural Resources prefers that students avoid the area during hunting season. Thus the trip occurs earlier in the seminar than is optimal given the current curriculum. The students now collect samples, save them, do the skill-building activities, and then return to their samples later in the semester to undertake the analysis. In the spring, we sometimes must battle weather, especially seasonal spring flooding. Over the past year, the department's faculty members have begun experimenting with other sites for the field trip. Some classes have gone to a local county park, and others have gone to the ISU Community Garden.

Further, depending on their area of concentration and on faculty members' disciplinary backgrounds, many students majoring in Earth and Environmental Sciences may learn more about social science research methods and theories emphasizing the human/community-environmental relationship before they approach material lending itself to physical research at a field site. A fruitful avenue to pursue would be to extend the human/community-environmental hypotheses in partnership with other departments or courses, to create more meaningful social and behavioral hypotheses. Nevertheless, the commitment for ENVI 110/L is to create a meaningful research experience that also reflects engagement with civic concerns.

Hypotheses, Sampling, Testing

As noted, the fieldwork site is Indiana's newest fish and wildlife area. Its location just a few miles from campus makes it possible to conduct the fieldwork within the time limits of the weekly 110-minute laboratory period. Prior to acquisition by the State of Indiana, much of the 2,400-acre tract was farmed, quarried, and used for illegal dumping. The field day serves as an important mechanism to collect soil samples, geospatial data, and biogeochemical samples to better understand how the once-drained bottom lands return to their more natural state. The goal of the experience is for each student to develop a hypothesis and test it by collecting at least two soil samples, taking GPS coordinates of each soil sample, and determining soil color, texture, nutrient status, and pH. The samples are dried and prepared for further analysis on campus.

Prior to the field trip, groups of students learn to develop a testable hypothesis. Lab activities leading up to the field day are aimed at building specific skills, for example learning how to determine soil texture, how to use test kits to quantify nutrients, and learning about contaminants in the environment. An entire day in the lab part of the course is devoted to the scientific method and development of hypotheses. Activities focus on developing a hypothesis that the students test and evaluate. Students are asked about the outcomes of



Professor Stephen Aldrich demonstrates the use of a GPS smartphone application.

flipping a coin, coming up with a sampling strategy to understand the layering of a candy bar, and trying to determine what might happen when two solutions are mixed based only on their initial observations. Because students are familiar with coins and candy bars, the outcomes of their experiments are predictable. The last activity, however, forces students to confront unexpected results. They mix warm milk and vinegar together and are surprised to find their final product is plastic.

In the lab session the week before the field trip, the students' preparation includes information on what a wetland is, why wetlands are important, and how they are threatened. This leads to information about the Wabashiki, its history, and its legal and (past) illegal uses. The purpose of this lab session is for each student to develop an individual hypothesis about Wabashiki soils and a sampling plan to address the hypothesis.

During the following week's field trip, each student collects at least two soil samples and records the following:

1. His or her sample GPS coordinates using a free smartphone application
2. Soil color
3. Texture
4. pH

The student also quietly observes the location and answers questions in a packet prepared for this trip. The packet includes a log for observations, a prompt about the kind of plant life has been observed (a minimum of two species), the kind of animal life observed (and if none is observed, the student is told to speculate about what kind of wildlife might live there), the way in which the wetland might benefit the wildlife, an explanation of any disturbances observed, an explanation about whether it is important to remediate the wetland area or not, methods for possible protection of the sanctuary, speculation on whether protecting the wetlands is beneficial to the student, aspects of the field trip that impressed the student, and changes in the trip that the student would recommend (and why).

Students have hypothesized, for example, that:

1. Soil samples with higher water content will have a lower pH.
2. Heavy metal concentrations will decrease with depth.
3. Soil pH will increase with distance from the pond.
4. Open areas will have higher metal concentrations than those with tree cover.
5. Former agricultural areas will have lower macronutrient levels than forested areas.
6. Nutrient levels will be higher at the bottom of slopes than at the top.
7. Soils closer to the "dump" will have greater macronutrient concentrations than soils in the former agricultural areas.

A student collects soil samples in the Wabashiki. The test kit is in the foreground.

Back on campus, students dry their samples, crush or sieve them, and use the spectrometer to collect data on soil elements. Considerable stress is put on the final report, and students are told that their data will be shared with the State of Indiana, thus assuring them that their work is important and not merely an academic exercise. Although the students work in groups, each student is required to submit an individual final report on the field trip.

The final written report must be a minimum of three pages and be written as a scientific report. A class handout provides detailed examples of the composition of the report, including two charts, two graphs of the data, and other specifics. Groups of students also prepare an oral report in the form of a PowerPoint presentation, which must be at least five minutes in length; all group members must speak and describe at least one slide. They must include their hypothesis, their testing strategy, all test results, and their conclusions.

Use of Collected Samples by Others

As described in the previous section, students prepare their soil samples following a protocol that makes them useful to the state's Department of Natural Resources. To date, other than "environmental monitoring," it is not clear how the agency is using the samples. The authors directly involved with ENVI 110/L report that the previous contact in the state department was more "hands-on" with the data than the current one.

However, author Aldrich prepared a comprehensive report for the department in fall 2013 following the introduction of the field trip and research project into the course. This report was based on 166 valid student samples with correct GPS coordinates; XRF data; and information on complete soil chemistry, texture, and color in most cases. Aldrich and a staff member conducted an initial analysis of the concentrations of four heavy metals—lead, nickel, arsenic, and mercury—at the Wabashiki. They found few samples with overly high concentrations of those metals. However, although they were few and sporadic, individual samples had extremely high levels of the metals. Aldrich and the staff member concluded that some samples "display heavy metal contamination from human impacts on the environment. While some areas show little to no contamination, other areas, and specifically dump areas, are higher in contamination" (Aldrich 2013, 50).

The data from the students' samples are used regularly in three Geographic Information Systems (GIS) classes, Introduction to GIScience, Introduction to Geographic Information Systems, and GIS: Applications. The data are also sometimes used in statistics classes.

To date, the authors are unaware of any students or faculty members using the data collected by the students in ENVI 110L for research, although some undergraduates have used the data for class projects in GIS classes.

Assessment of the Research Experience

Faculty members created a survey that students filled out in fall 2014 that directly assessed the field trip and research project. Unfortunately, spring rains made the field trips impossible and evaluations unnecessary in spring 2015. In fall 2015 rains made it impossible for some lab sections to complete a field trip.

At ISU, students are asked multiple times to evaluate their courses via an online system, but evaluations of the ENVI 110/L field trip are conducted through a survey administered via the Learning Management System (LMS, Blackboard). Although online evaluations yield lower response rates than paper-based questionnaires in most cases, students report confusion with the LMS survey, and response rates suffer significantly. There is a plan to administer the survey differently to avoid this problem in the future.

Students are asked to answer 19 questions on the LMS survey using a five-point Likert scale. Five indicates "strongly agree," and 1 indicates "strongly disagree." A 3 indicates "neither agree nor disagree." Table 1 contains average scores and standard deviations for fall 2014 and fall 2015.

Most item averages vary less than one standard deviation from each other, suggesting consistency in the students' ratings. The scores also suggest that students generally agree with the statements but without much intensity. Future evaluations may ask students to compare the field trip to conventional lab experiences, altering the response categories and modifying the wording of some questions.

The survey results thus far suggest the field trip is perhaps slightly more successful at aiding "understanding of environmental issues globally and in my community" than in improving confidence in "my abilities as a scientist." However, even higher averages were obtained for the statement that the research project helped a student to "better understand how to develop and test a hypothesis," a necessary skill for gaining confidence as a scientist and becoming a critical consumer of scientific reporting.

It may also be that scientist is not something that many students in the course aspire to be or identify with. Among the highest average numbers were the responses to "I learned some skills and knowledge about environmental science that I could not have learned in a classroom." This, we think, is

Table 1. Student Perceptions of the Environmental Sciences Fieldwork

	Fall 2014		Fall 2015	
Question	average (n=195)	standard deviation	average (n=83)	standard deviation
Participation in the field trip was a rewarding experience.	3.90[a]	0.93	3.81	0.97
As a result of the field trip, I understand environmental science better than before.	3.79	0.78	3.71	1.07
I felt well prepared for the field-trip activities.	3.70	1.09	3.72	0.97
I learned some skills and knowledge about environmental science that I could not have learned in a classroom.	3.96	0.90	3.77	1.007
Overall, I think the field trip has enhanced my learning and interest for the course.	3.65	0.97	3.57	0.98
Field-trip activities were worthwhile.	3.75	1.05	3.61	1.04
I was able to use skills I learned in class on the field trip.	3.93	0.94	3.77	1.13
This field trip had a significant impact on my learning for the course.	3.63	0.99	3.41	1.04
Field instructors provided clear instructions and guidance.	4.04	0.97	3.9	1.02
I enjoyed the field trip.	3.61	1.16	3.51	1.11
The field trip was a valuable use of my time.	3.60	1.06	3.49	1.15
The field trip was well organized.	3.92	0.84	3.61	1.02
I enjoyed the research project.	3.50	1.03	3.24	1.10
After completing the research project, I better understand how to develop and test a scientific hypothesis.	3.88	0.74	3.73	1.03
The research project was a good use of my time.	3.42	1.00	3.49	1.06
Were you aware that your data will be shared with the Department of Natural Resources?	NA	NA	45.8% Yes	0.50
The research I completed is important to the community.	3.88	0.90	3.61	0.93
After completing the field trip and research project, I am more confident in my abilities as a scientist.	3.62	0.78	3.48	1.04
After completing this course, I have a better understanding of environmental issues globally and in my community.	3.84	0.75	3.85	0.91

[a]A 5-point Likert scale was used with the following elements: 1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree

the strongest student-evaluation evidence for the efficacy of the field trip and research project, and a good reason for others to develop similar research projects in comparable courses.

We conclude that the students' evaluation data, on average, supports the following conclusions:

- The field-trip research experience and research project were rewarding and worthwhile experiences for students, and they enhanced students' learning in the course.
- Students learned skills and knowledge they would not otherwise acquire in the classroom, and those skills are useful.
- The field trip and research project led to better understanding of environmental science, the scientific process, and global and local environmental issues.
- The students understood that their research efforts contributed to the local community.

Discussion and Conclusion

ISU emphasizes experiential learning and community engagement as core values. To that end, there is a supportive institutional setting for a logistically challenging field trip and research project for the mostly first-year students enrolled in ENVI 110/L. Even in such a supportive environment, however, resources are tight, and the experience requires faculty who are personally dedicated to the experience. Our experience shows that, although unsettled times may seem to support a conservative approach to curricular innovation, departmental or university upheavals may also be fertile moments for initiating significant change. Given this, the experience of ISU faculty with ENVI 110/L leads to some concrete suggestions:

Identify a site. Getting students out of the lab and into the field begins with identifying a place nearby. ISU is fortunate that the Wabashiki is so close to its campus. Other possible field sites could be city/county parks, brownfield sites, redevelopment sites, campus grounds, local school grounds, or cemeteries—the possibilities are many. Approaching the managers of the site is necessary to gain access but also to make the project meaningful. It is possible that the local park district might appreciate the environmental monitoring that annual or semi-annual soil samples (or water samples) would provide. It is also possible that some financial support could be part of the partnership to help offset the added costs of the field trip, sample processing, and database management. By routinely returning to the same site, faculty also gain experience; the process becomes more standardized, and the accumulated data becomes a more valuable resource for possible uses in the classroom or for undergraduate researchers completing their own research projects for capstones, senior theses, and other projects.

Start small. Do not try to take hundreds of students into the field the first time. Pilot the field trip with a single lab section. The current ENVI 110/L field trip and research project resulted from several years of iterations, leading eventually to the creation of a handbook on how to prepare students for the trip and how to efficiently and effectively organize students on the day of the trip. The activity takes experimentation and refinement. Ramp up slowly but steadily to inclusion of all class sections.

Seek support. Check on whether there are any funds for curriculum transformation or to support "community engagement" or course-based field trips. If there is an office for undergraduate research on campus, perhaps the staff could also support the effort.

Partner with students. Ask them what they like and dislike about the experience and look for good ideas from them. The faculty who developed the ENVI 110/L field trip received several good ideas from students about how to improve the experience. Our end-of-semester student evaluation contains an open-ended question about suggestions for improvement.

Don't fear failure. We tell our undergraduate researchers that failure is part of research, so faculty also shouldn't be discouraged by initial setbacks while piloting a field trip and research project. There will be logistical challenges. For example, some students may wait until the last minute to complete the testing of their samples, thus overwhelming available lab space, or local officials might change their minds about partnering in the endeavor. The weather at times will not cooperate. Let students know that something new is being tried, and they will accept that some plans do not work perfectly.

Persist. The experience is worth it for the students, plus it can lead to positive town-gown relations and can generate positive local publicity for the institution. Furthermore, long-term collection of data can drive forward meaningful science and develop ideas that may bear fruit for both classroom instruction and future research.

Acknowledgments
The authors acknowledge the contributions of department faculty members Susan Berta and Jeffrey Stone to the success of ENVI 110/L. We also acknowledge the contributions of Tiffany Grossman to the 2013 report to the Indiana Department of Natural Resources and the lab instructors' manual for guiding the field trips.

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doi: 10.18833/curq/37/1