2006-1102: CRITICAL CONNECTIONS: A FIRST-SEMESTER COURSE IN ENVIRONMENTAL ENGINEERING

Kurt Paterson, Michigan Technological University

Critical Connections: A First-Semester Course in Environmental Engineering

Motivation

Many engineering programs have moved to a common first-year structure. The benefits of such an approach are many, and most notably account for the challenge in selecting a major with certainty prior to becoming a college student. For all the benefits, one major disadvantage of the common first-year is the loss of connection to the “family” embodied in the students and faculty within the major. Simply put, most first-year students are not connected to the program they are so excited to be part of. Student motivation and retention are also special concerns during the first year. This paper introduces a new course introduced to the environmental engineering program at Michigan Technological University (Michigan Tech) to address these and other issues. The course objectives, structure and outcomes are provided herein.

Course Objectives

A new first-semester course in the undergraduate environmental engineering program at Michigan Tech, *Experiences in Environmental Engineering*, was added to the curriculum in Fall 2005. This course introduces students to the knowledge, skills, and attitudes needed along the path from environmental engineering student to environmental engineer. Specific course objectives have the students:

• form a community within the university;
• establish friendships among students of similar academic interests;
• develop an academic plan;
• develop skills to deal with the many aspects of student life;
• learn more about the university’s environmental engineering program;
• develop a sense of the environmental engineering profession;
• use some of the skills required by environmental engineers;
• explore several of the specialty areas within environmental engineering;
• master some of the basic environmental engineering language; and
• use knowledge gained to make better career choices

While many of the topics in the list above are connected to environmental engineering, the primary agenda of the course is to cultivate an enthusiasm for active participation in the environmental engineering community. This recognizes the importance that a sense of belonging has on student enthusiasm, participation, and success.

Course Structure

The course is a one-credit offering, meeting once a week for up to three hours. The pedagogical model of the course, expressed through its title, is experiential learning. Extinguishing student enthusiasm with a first course composed of lectures would undermine the primary objective; hence the three-hour block of time that permits a wider range of learning opportunities. The weekly class meetings are a mix of topics, roughly one-third focus on contemporary environmental issues, one-third on general student issues, and one-third on professional issues. Several professors, staff, and senior students lead the sessions. One common thread among the students electing to major in environmental engineering is their desire to help (save) the world. The students arrive with considerable knowledge about environmental issues, and substantial opinion on what to do about the problems. To capitalize on this knowledge base students are required to use a WebCT-mediated discussion board to post, review, and discuss articles on environmental topics. Lastly, to ensure that some deeper connections are made in the class students are required to work on a term project in a small team.

Course Outcomes

This first offering of *Experiences in Environmental Engineering* had twenty-three students (48% women, 52% men). In the sections below, findings on learning preferences and outcomes are revealed.

Learning Preferences

To examine the appropriateness of the course design all students were evaluated for learning style preference. No two students learn alike. There are two primary reasons for this: intellectual development, and learning preferences[1]. Both have genetic and cultural roots. While intellectual development is a measure of the maturity of the student's mind and has been a favorite molding target of passionate teachers everywhere, learning preference is less easily influenced. Learning style is simply a preferred way of learning – often the way(s) that knowledge "sticks" most easily. While the diversity of learning styles can be a source of frustration for educators (one blanket teaching method is grossly inadequate for maximum learning), it can also be used to design more effective courses.

There are several methods to assess learning preferences[2]. One method particularly suited to science and engineering students is the Index of Learning Styles (ILS)[3]. In this method learning preferences are determined via a web-based 44-question survey with results along a spectrum of four learning pairings: verbal-visual, global-sequential, sensing-intuitive, and active-reflective[4]. The learning style preferences for this class are summarized in Figure 1.

Among the students, there is a rough balance between the big-picture global learners (52% of the students) and the orderly step-by-step sequential learners (48%). Nearly two times as many students learn best through sensory input (65%) versus intuition (35%). The preference in the visual-verbal pairing is more skewed, nearly five times the number of students have a preference for visual learning (83%) versus verbal learning (17%). Lastly, for every student who learns best by reflecting on material (13%), there are almost seven who prefer active learning (87%). These results are similar to past ILS studies of environmental engineering students[5]. Clearly, a lecture-based course would not be ideal for these students. These results are not a call to completely abandon lecture, nor activities that require students to use a non-preferred style (everybody can learn in all modes), rather it is evidence to suggest a course design that could be more effective by offering a variety of strategies. At the least, this learning style evidence does suggest the course name, *Experiences in Environmental Engineering*, is more in the spirit of the active students than, say, *Introduction to Environmental Engineering*.

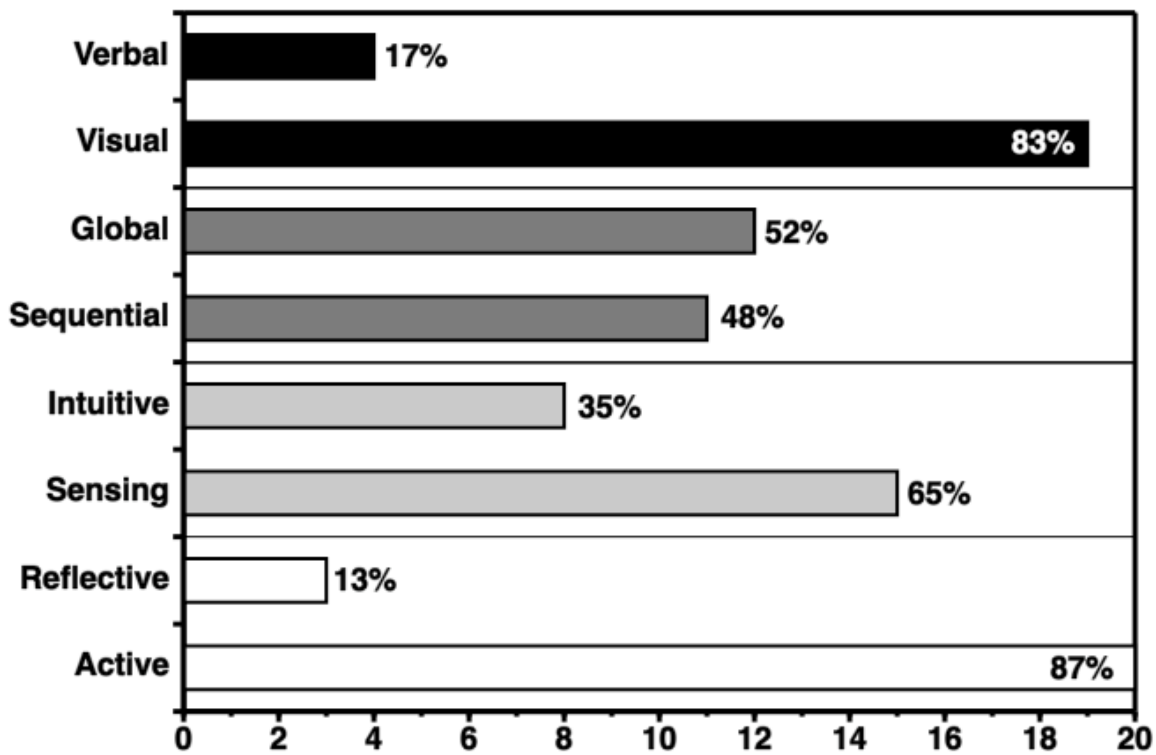

Figure 1. Student learning preferences among first-year environmental engineering majors, Fall 2005 (n=23)

Classroom Sessions

The classroom sessions are designed to provide a variety of experiences to the students, most having a combination of professional skill development, environmental engineering fundamentals, and student discussion. The instructor (author) leads many of the sessions; other sessions are led by juniors and seniors (Weeks 11-13), one by the academic advisor (Week 6), and three by other faculty in the program (Weeks 4, 7, 9). Table 1 shows the general topics covered. The main constraint on all class leaders is that no class session can be 100% lecture, ideally the students should be engaged part of the time with active learning and discussion. This objective is the main reason for reserving a three-hour block of time for the course. This full amount is used for about half the classes. Around 30% of the classes are two hours, the last 20% only an hour, particularly near the end of the semester to allow students to focus on the classes with their first finals. This is an especially salient point – upon discussion of workload with students, most are struggling with the demands of studying for the first times in their lives. A sympathetic course design tapers the course demands in the post-Thanksgiving period.

Table 1. Weekly focus themes for *Experiences in Environmental Engineering* classroom sessions

Week	Class Session Topic
1	Great things about you, our program, our profession
2	Planning your academic career
3	Fundamentals of research
4	Exploring a really big lake aboard a research boat
5	Investigative reporting at the University's career fair
6	What courses come next? Why?
7	Water crises around the world
8	A mid-term celebration: getting together outside of class
9	How environmental engineering serves the global community
10	What? Air can kill people?
11	Talking about senior design three years in advance
12	International education opportunities
13	After your first year: where can you work in the summer?
14	The power of service: using environmental engineering to do good

Virtual Sessions

A weekly web-based component of the course is used to extend learning and interaction beyond the classroom. These virtual class sessions also acknowledge the students' adeptness with internet-based communication, collaboration, and community. WebCT is used as the framework to support an online discussion board with the purpose of probing a different environmental topic each week[6]. This is done to assess: student interests within a theme topic, the depth of knowledge students have on environmental issues prior to their university education, and their ability to effectively present their point of view. Each week one-quarter of the students are charged with finding and posting an article (from an online edition of a journal, or from a news web site) within the environmental theme, the other three-quarters are required to read one of those articles and post their thoughts. The instructor also provides short comments and open-ended questions to many of the postings each week. Table 2 lists the environmental topics for exploration in the virtual sessions.

Several conclusions can be drawn from the virtual class sessions. First, there are no problems among the students in using the discussion board technology; as the average age of students in this class is 18, this is not a complete surprise. However, it does suggest that the students are not the limiting step in effectively implementing such course tools. Secondly, the students have an amazingly high level of discussion via the technology. Few rules are imposed on the students regarding length or depth of post (the primary objective for these sessions is to get the students thinking about various environmental topics and various points of view), but most students provide thoughtful (if not always accurate) commentary. Having time to reflect and then compose their thoughts results in more uniform discussion participation too, compared to a real class setting. Lastly, the students report a high level of interest in this activity.

Table 2. Environmental discussion topics for the WebCT-based virtual class sessions for *Experiences in Environmental Engineering*. Weeks 1 and 14 have no such sessions.

Week	Virtual Session Topic
1	--
2	Human population
3	Urbanization
4	Water resources
5	Solid waste
6	Energy
7	Human health and the environment
8	Air quality
9	Major environmental problems in developing countries
10	Major environmental problems in developed countries
11	Climate change
12	Biodiversity
13	Sustainability
14	--

Term Report

To provide research, communication, and teamwork experiences, the students are charged with writing a short technical report within a theme (electronic waste). The student groups develop a specific topic within the e-waste theme, propose a work plan, refine both via meetings with the course instructor, and present the work publicly via PDF file reports on the course web site. In addition to the above-mentioned goals, this project has another powerful objective – getting students comfortable meeting with a professor in their office. With the exception of one underperforming group member, the results are uniformly excellent. Students have interesting project ideas (presented in Table 3), come to the faculty meeting with good work plans, work well in groups, and produce well-written technical reports.

Table 3. Student-selected term report topics

Team	Topic
1	Hazardous components of cell phone e-waste
2	The price of dismantling e-waste to developing countries
3	Electronic waste and its effects on aquatic ecosystems
4	Fluorescent light bulbs
5	What happens to old CDs?
6	Electronic waste: legislation at the federal level

Other Outcomes

Short-term assessment of the course is accomplished through a short survey focusing on the environmental engineering profession and program at Michigan Tech. Some of these findings are provided in Table 4. The results are surprising and encouraging. The first two questions in Table 4 focus on choice of environmental engineering as a major, and reveal the importance of classes such as this one. Deciding on a profession at age 18 is an immensely challenging task. University programs need to provide opportunities for students to discover what they find interesting, and then offer easy transition paths to other majors should they be needed. On first examination, the main finding from the first two questions is that the students become less certain about their choice of environmental engineering as a major. What is lost in the average, however, is the Final Day response becomes extremely bi-modal. One cluster is in the 1-2 response range (sure to stay in major), another in the 8-10 response range (sure to change major). The class effectively helps the students decide whether environmental engineering is for them, and leaves a group highly committed to the major. Typical reasons for being less satisfied with environmental engineering include discovering: environmental engineering work is often done in an office setting (versus outdoors); that mathematics is a core body of knowledge; that the major requires mastery of physics, chemistry and biology; and that animals are not a primary focus of the field.

The latter two questions in Table 4 focus on community. Four environmental engineering professors interacted with the students; the course designer (this author) during ten class sessions, one professor for two class sessions, and two professors for one class session each. Students report an increase in the number of faculty they can identify. The average number of friends within the program decreases from Day 1 to the Final Day, but both numbers are so high this may simply be a “counting” artifact by the students. It is also important to note the large spread for the “number of friends” question – there are always students who struggle to make friends (even for the typically extroverted environmental engineering majors), and as such they may be at additional risk for retention and success (perhaps it is a similar story for those with too many friends).

Table 4. Environmental engineering student assessment results (average response for class provided, n=23)

Question	Response (Day 1)	Response (Final Day)
1. Do you think you will stay in this major until graduation? (1 is sure to stay, 10 sure to leave)	2.75	5.00
2. How content are you with your choice of environmental engineering as your major? (1 is happy, 10 is unhappy)	1.73	3.65
3. If you saw photos of the environmental engineering faculty, how many could you identify by name?	1.48	2.56
4. How many environmental engineering majors are you good friends with?	9.43	8.04

Additional formative assessment is simply gauged by interacting with the students and observing behavior. Long-term benefits will be measured through evaluation of retention data and senior exit interviews. As the first offering of the course just concluded, these latter two will not be possible until further time has transpired.

Two other major observations are noted, one involving student readiness, the other *esprit de corps*. As evident on the WebCT discussion board, and reported by every one of the classroom session leaders, the level of discussion is impressive among these new students. Environmental engineering may benefit from a decisively focused student body – they are getting a degree to "help save the world" and many are fairly well educated on environmental issues. Tapping into that motivation results in energized class sessions. It also suggests that other (lecture-driven) classes are under-utilizing a substantial reservoir of knowledge. On the first day of the class, the instructor heard the students well before entering the classroom. The students were talking energetically in clusters. The students revealed that they knew each other well through a week of cohort activities during Freshmen Orientation. Group-building activities are not as necessary as thought in this course, but are still important; not all students are gifted at building friendships quickly. While camaraderie improves even more over the course of the semester, it is clear that a huge determinant of *esprit de corps* is class and program size. Universities everywhere should understand the diminishing returns for programs with greater than twenty-five or so students per class. Another engineering program (with more than 100 students in its freshmen class) ran a similar first-semester course for the first time in Fall 2005. Due to the large class size, each class is lecture-based and professor-centric. A small (unscientific) student poll reveals less enthusiasm and connection to their academic community, compared to the environmental engineering students. Students can certainly persevere through such programs, but little is gained through such quantity, instead of quality, driven approaches (other than tuition revenue and program size bragging).

Summary

Results to date suggest the *Experiences to Environmental Engineering* course is a success: student camaraderie is high, students are in a more informed position regarding their major selection, students are exposed to a more-balanced student-centered course design, and students have stronger connections to the environmental engineering community at Michigan Tech. Improvements next year include an opening day ceremony with all environmental engineering faculty in attendance, better presentation of career possibilities, and more hands-on experiences.

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