Paper ID #6254

Interdisciplinary, real-world, client-based term projects in an introductory environmental engineering and science course

Major Andrew Ross Pfluger, P.E., United States Military Academy

Major Andrew Pfluger is an officer in the United States Army and an Assistant Professor at the United States Military Academy (USMA) in the Department of Geography and Environmental Engineering. He holds two graduate degrees from the Department of Civil and Environmental Engineering at Stanford University and is a Professional Engineer in the State of Delaware. He current teaches Environmental Science, Environmental Engineering Technologies, and Air Pollution Engineering.

Major Matthew P. Baideme, United States Military Academy

Major Matthew Baideme is an officer in the United States Army and an Instructor at the United States Military Academy (USMA) in the Department of Geography and Environmental Engineering. He currently teaches Environmental Science and Environmental Engineering Technologies at USMA.

Mrs. Katie E Matthew, United States Army

Major Katie Matthew was commissioned as a Logistics Officer upon graduation from the United States Military Academy in 2000. She has served and commanded in a variety of units, to include maintenance, supply, and headquarters for combat brigades both stateside and deployed. She received an MBA from Kansas State University in 2009 and has taught courses in military leadership and marketing at West Point for the past three years.

Major Stephen A. Lewandowski, United States Military Academy

MAJ Lewandowski serves as an Environmental Science and Engineering Officer in the U.S. Army Medical Service Corps. He is an instructor in the Department of Geography and Environmental Engineering at USMA, West Point, NY.

B.S. United States Military Academy, Environmental Science (2002) M.S. Harvard School of Public Health, Environmental Health (2011)

Lt. Col. Jeffrey Allan Starke, United States Military Academy

LTC Jeff Starke is a Military Intelligence officer with command and staff experiences at the battalion, brigade, and joint task force levels. His most recent experiences include operational intelligence assignments in support of Operation Enduring Freedom, Afghanistan. Academically, LTC Starke specializes in environmental engineering with research and teaching interests in drinking water, public health, and microbial-mediated renewable energy resources. LTC Starke teaches senior-level design courses in Physical and Chemical Processes, Biological Treatment Processes, Solid and Hazardous Waste Technologies, and Environmental Engineering Seminar. LTC Starke has published over 10 peer reviewed research articles and has presented his research at national and international meetings (most recently Portugal). Most recently, he led a service learning project with 5 students to build a latrine-based biogas system in western Uganda for an elementary school of 1400 students. LTC Starke is a registered Professional Engineer (Delaware), member of several professional associations, and is a member of the National Council of Examiners for Engineers and Surveyors (NCEES).

Dr. Michael A. Butkus P.E., U.S. Military Academy

Interdisciplinary, real-world, client-based term projects in an introductory environmental engineering and science course

Abstract

Many universities have real environmental problems in areas such as energy efficiency, water efficiency, and solid waste management, but do not always have the time or resources to examine the problems in depth. The United States Military Academy (USMA) employs an introductory environmental engineering and science course required for environmental engineering and environmental science majors, which is taken during the first semester of their junior year. Additionally, USMA requires that all non-engineering majors take a three-course engineering sequence, and a slightly modified version of the introductory course is taught each year to approximately 170 such students in the first semester of their junior year. Within the context of the course, we maintain a semester-long term project that examines real environmental problems, which our student teams (3-4 students of varying academic majors) observe or clients (such as the Department of Public Works or our student government) identify. Preparation for the project requires student teams to develop a hypothesis and a basic sampling and evaluation protocol. Students then use the protocol to conduct sampling in the local community and analyze results in light of their hypothesis. Students are required to submit a final written report. This term project model also encourages interdisciplinary collaboration with non-STEM disciplines, such as the Marketing course in USMA's Department of Behavioral Sciences and Leadership. This cross-cutting educational method can create more holistic solutions to the identified problems and enhance student learning. To date, assessment of students who participated in the real-world, client-based project versus a general environmental project indicated an improvement in several important areas: valuation of results, motivation and understanding, and confidence in problem solving skills. This work presents the methods our program developed to incorporate the scientific method, hypothesis development, and sampling methodologies to help solve these relevant real-world problems. The methods required to implement this educational experience in environmental engineering programs to meet ABET accreditation requirements are also discussed.

(1) Introduction and Background

All environmental engineering and environmental science majors at the United States Military Academy (USMA) begin their educational experience with an introductory course (titled EV301) taken in the first semester of their junior year that incorporates basic principles of environmental science. A modified version of the course (titled EV300) is taught to approximately 170 non-engineering majors each year to fulfill our university's requirement for all non-engineering majors to take a three-course sequence in an engineering discipline. EV300 and EV301 each possess 40 1-hour lectures, which are divided into 4 blocks of instruction: ecology, risk, energy, and pollution. Within the context of both courses, our students complete a semester long term-project. The purpose of the term project is to teach students the scientific method for problem solving through experimental design. Prior to the 2011-2012 academic year, project topics focused on basic environmental science problems, examples of which included determining water quality, determining the effect of water runoff from surfaces to lakes or streams, and determining the effect of road salt on plant growth. In the 2011-2012 academic year, two sections (28 students) conducted a pilot study to determine if community-based term projects focusing on solid waste, energy, or water problems that students and university employees see in the community would increase student interest and learning. Several sources[9,10] indicate that implementing course projects in a real-world context not only increases the pride students take in the results, but also benefits the community. To effectively integrate project teams and the community, each project team (approximately 4 students) found or was assigned a client in the community. In some cases, clients requested that student teams focus on a certain environmental issue with which they required assistance. Due to initial success in 2011, the community-based project concept was made available to all students in EV300 and EV301 for the 2012-2013 academic year. The project description section of this paper focuses on the approach used in EV300 for the 2012-2013 academic year.

Due to the nature of student enrollment in EV300 and EV301, the term project teams are comprised of students from different academic majors. This diversity allows for students with different skill sets and interests to solve a common environmental problem. Additionally, to enhance interdisciplinary collaboration, faculty in our academic department established a connection with our university's marketing course (titled MG380). The goal of the interdisciplinary, or cross-cutting, collaboration was to create more holistic solutions, which would enhance student learning while, ideally, creating a solution more easily implemented by the client. Alden et al (1991) gives several reasons for utilizing cross-disciplinary approaches to solving complex problems at the undergraduate level, each of which focus on increasing problem solving skills and enriching the educational experience.[2] Interdisciplinary collaboration focused on sustainability topics, such as energy and the environment, uniquely benefits students studying in different disciplines.[8] Providing students the opportunity to develop solutions to energy and environmental problems helps shape behavior and promote lifelong dedication to sound environmental practices.[12] Additionally, engineering and science students can possess a void in "human" skills, such as communication and teamwork;[14] skills that an interdisciplinary project can enhance. Likewise, marketing students can lack the ability to market sound engineering solutions without a strong prior knowledge base. Exchange relationships, such as interdisciplinary projects, can overcome that problem.[11] Precedent in published literature for developing coordination between marketing and engineering courses is available;[13] however, there is no readily available literature that couples a junior-level environmental engineering term project and a junior-level marketing term project.

(2) Project Description

The EV300 and EV301 term projects present students with an opportunity to explore their local environment, work in a team to identify an energy or environment issue they feel is important, and develop a solution. Students are instructed to apply the scientific method to solve this need by developing a hypothesis that can be tested through data collection and interpretation. They design and conduct environmental research, and apply the results of their research toward a recommendation for an engineered design or specification. The following four steps provide a description of how the term project is presented to students and implemented.

Step 1: Introducing the Scientific Method

Prior to the introduction of the term project, faculty dedicate two class lessons at the beginning of the semester toward discussion of the steps of the scientific method (as described in Botkin-Keller, 2011)[7], developing testable hypotheses (Fig. 1) and experimental design, developing viable research methods, and introducing the course term project.

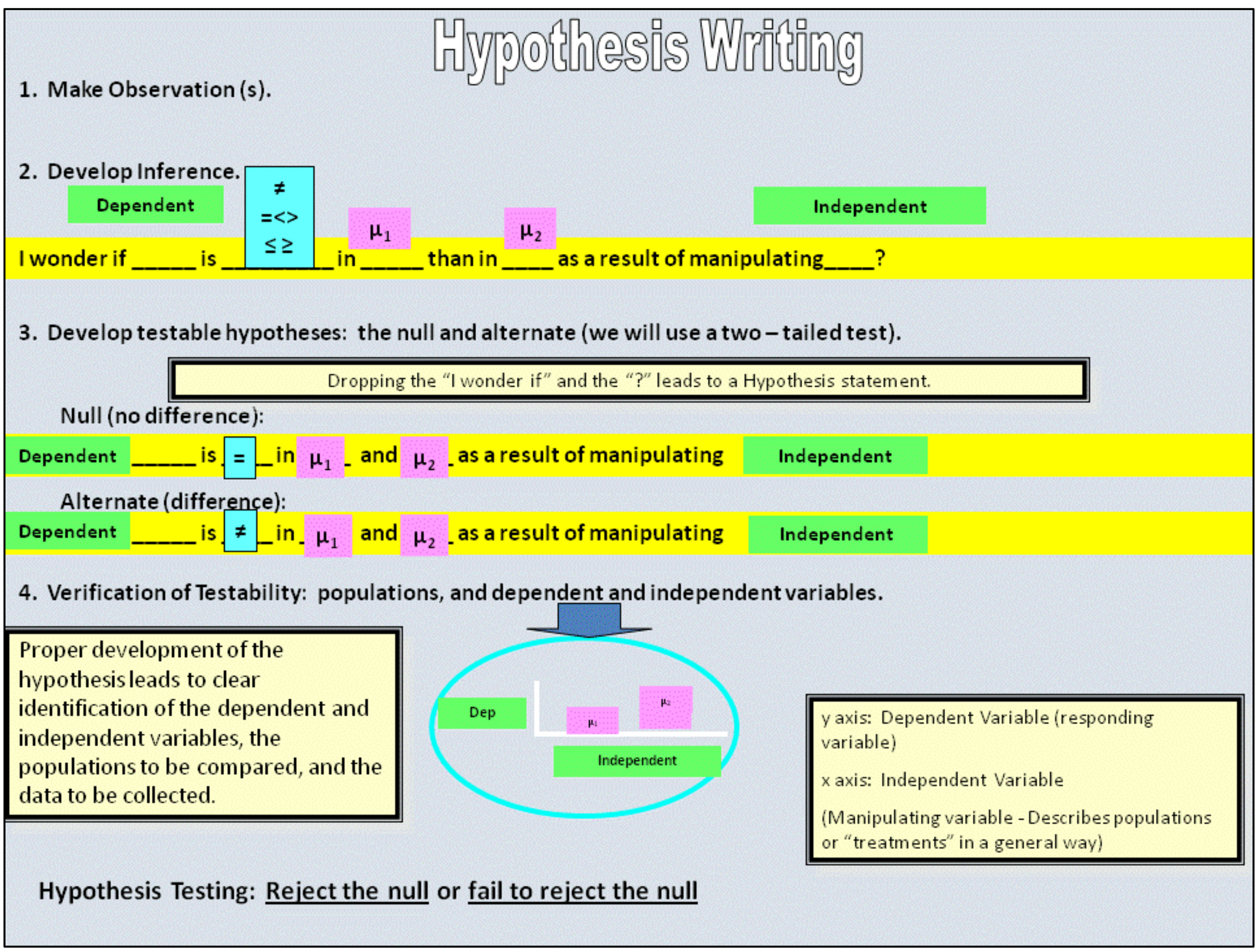

Figure 1. EV300 handout on how to construct a hypothesis. This method is based on the scientific method presented in Botkin and Keller (2011).[7]

In these lessons, instructors emphasize critical thinking and the differences between scientific and non-scientific approaches. Instructors pay particular attention to research methods, emphasizing the statistical tests of significance that students will use to test their hypotheses such as the Student t-test and Analysis of Variance (ANOVA) methods.

Step 2: Term Project Topic Selection and Client Relationships

Student term project groups are given freedom to select any topic they are interested in, based on observations and inferences they have made. Students are provided guidance that the project must apply the scientific method to better understand an environmental-based problem, develop a hypothesis that can be empirically tested, and be able to complete the project given time and resource constraints.

To help guide topic selection, instructors encourage students to look for issues in their immediate vicinity (student dormitories, academic buildings, sports fields), as well as in the surrounding community (approximately 6000 people). Several topics are those identified by "clients" in the local community. While the examination of some ideas is challenging with restrictions on transportation and time, many environmental problems exist in the immediate student area. Student groups that select client-based projects communicate findings to the appropriate stakeholders and authorities on the university campus. Clients, meanwhile, provide added value by identifying relevant projects, serving as mentors, and providing feedback on the student's work. Examples of active clients during the 2012-2013 academic year, as well as potential clients for future academic years, are listed in Table 1.

Table 1: Current clients for academic year 2012-2013.

Current Clients[a]
Student Environmental Leadership Organization (43 students) – organization focused on identifying and solving environmental problems and increasing environmental awareness.
United States Corps of Cadets (approximately 70 faculty and staff) – organization that is focused on the military development of cadets at the United States Military Academy. They incorporate environmental concerns in various aspects of student military training.
West Point Energy Council (10 faculty and staff) – committee of academic faculty and public work staff dedicated to improving the environment at the United States Military Academy.
Department of Public Works (5-10 staff) – personnel whose job is to maintain the infrastructure and improve the environment at West Point. Students specifically coordinate with personnel in the Environmental Management Division and Natural Resources Branch.

[a] Potential future clients include the Environmental Health Section of the Preventative Medicine and Wellness Department at our hospital, and the US Department of Energy.

One of the primary areas of emphasis for the clients (Table 1) is the Department of Defense and Department of Energy's emerging "Net-Zero" Energy program, in which the United States Military Academy is one of only a small number of military installations selected to participate. This designation represents a "concept of energy self-sufficiency based on minimized demand and use of local renewable energy resources," that ultimately leads to the on-site production of renewable energy equal to energy demand.[6] Other components of the overarching Net-Zero initiative include water conservation and waste reduction. Provided this background, many student project groups chose to investigate Net-Zero-related issues during the 2012-2013 academic year (Fig. 2).

Students are also given the option to pursue basic research experiments that are related to course objectives and can be applied to better understand environmental problems. Examples of suggested experimental projects include plant-based bioassays to assess toxicity and assessment of composting effectiveness, based on manipulation of one or more variables.

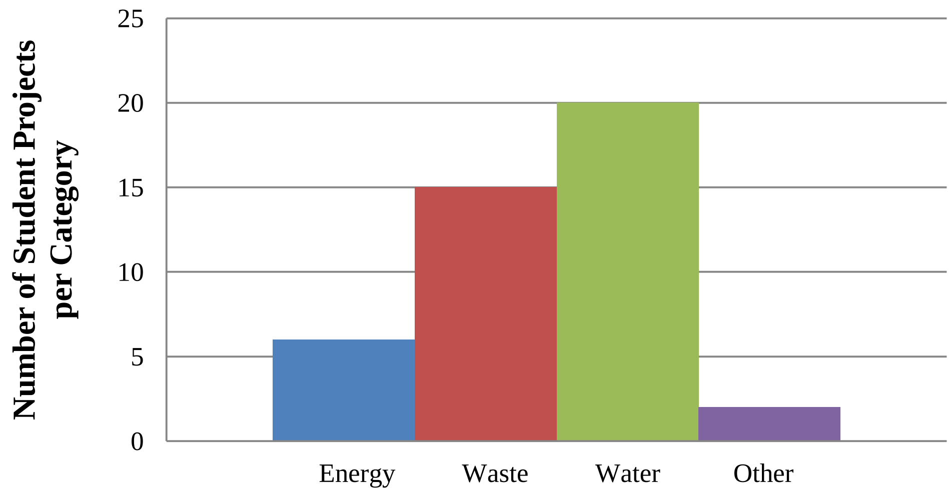

Figure 2. Fall 2012 EV300 Net-Zero Related Projects

To facilitate the selection of effective term projects, and to build upon previous results, we provided students with summaries of environmental projects from previous terms. To advance this technique, instructors implemented a new project database during the 2012-2013 Academic Year that will allow instructors to longitudinally track all types of projects. Since this high enrollment course is taught by multiple faculty members, the database will also allow faculty new to the course the ability to view a historical record of term projects.

Student groups are required to develop five term project ideas and present them to the instructor as null hypotheses during Milestone 1 (see following section and Table 2). The instructor works with each project team to determine the most feasible project based on constraints such as time and equipment.

Step 3: Project Execution: Timeline and Milestones

A timeline with milestones is given to students on lesson 1, which provides an introduction to the project early in the course, and guides them to complete the project in manageable sections (see Fig. 3). Table 2 outlines what is required of student project teams at each milestone. Instructors reserve time in-class for an in-progress review (IPR), which is designed to identify problems while there is still time for students to correct them. Points are assessed for completion of the milestones, although the final report accounts for over 68 percent of the cumulative term project grade (Table 2). Overall, the term project comprises 22 percent of the final course grade in EV300 and EV301.

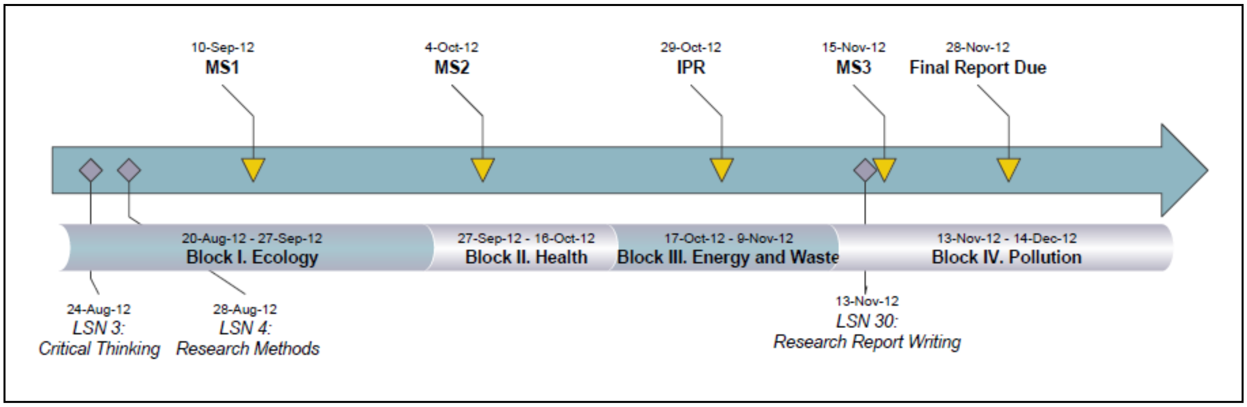

Figure 3. EV300 Term Project Timeline during the fall semester of 2012. The course is organized into four blocks, illustrated by the bottom bar.

Table 2. EV300 Term Project Milestones. EV300 is a 40-lesson course.

Milestone	Lesson	Requirement	Points
1	8	Hypothesis writing (write five null hypotheses)	10
2	17	Introduction (with literature review), Hypothesis and Methods	25
IPR	25	In-progress review with Instructor	0
3	31	Data collection: Tables and Figures	20
Final Report	34	Final project report submission	150
Peer Assessment	34	Group contribution evaluation	15

Step 4: Project Submission and Peer-Evaluation

Students are asked to submit the report in a standard science and engineering format[4,5] and include the following five sections: introduction, materials and methods, results, discussion, and conclusions. There is no minimum or maximum required length to the final report. The usual length of report varies from 8 to 15 double spaced pages. Students are graded on the quality and clarity of each individual section. Of note, the introduction section is required to include a brief literature review which refers to at least three sources outside of the course text. Our university does not have teaching assistants, so instructors facilitate and assess all projects.

Students who chose the community focused, client-based term project are sometimes asked to present their findings to clients outside the context of the class depending on the quality of their results. Students do not receive credit for their involvement in briefing or implementing the project outside of class; however, many students express interest in seeing their project findings considered for implementation.

In addition to the final report, students are required to complete a peer evaluation, which provides an indication of group dynamics. Students are asked to provide an honest assessment of each group member's relative contribution as well as their own. This component makes up less than 7 percent of the project grade (15 points), but it adds to a sense of fairness in that individuals who contributed less do not receive exactly the same grade as those who put in the most work. This score is not evaluated as a "zero-sum" measure. It is possible for all members to receive the maximum points, if their contributions were equivalent and the work is of high quality.

(3) Applicability to ABET for Students Majoring in Environmental Engineering

All students at our university are required to complete a 30 course core curriculum, which is primarily completed in their freshman and sophomore year, and contains approximately 3 credits of engineering topics (ET). Generally, all courses at our university in ABET accredited engineering majors contain ET to achieve the 48 ET credit hours required by ABET EAC criterion 5.[1] Consequently, students choosing environmental engineering as their major take EV301, which offers 2.0 credits of ET. Since the content of the described project could consist of basic science (BS) or ET, instructors must carefully consider the students' chosen topics. As of academic year 2012-2013, students taking EV301 are required to complete an additional engineering design component of the project to assist in meeting ET credit. Since instructors must ensure sufficient ET credit can be justified, instructors assist students in selecting projects that meet the above project criteria while allowing the environmental engineering students the ability to complete the additional design step. Since the project groups are not solely comprised of environmental engineers (see Table 3), ABET student outcome "d" is also satisified.[1] Of note, in addition to ABET accreditation, the partnership between EV300, EV301, and our university's marketing course (described in section 4 below) assists our university's Department of Behavioral Science and Leadership in meeting accreditation with the Association to Advance Collegiate Schools of Business (ACCSB).

(4) Interdisciplinary Collaboration

Collaboration 1: Course Enrollment

Interdisciplinary, or cross-cutting, collaboration can occur on two occasions in the course project. The first point of collaboration is within the context of the groups themselves, based on the nature of the course enrollment. Tables 3 and 4 indicate the enrollment in EV301 and EV300 during the first semester of academic year 2012-2013. As shown, EV301, which is taught to environmental engineering and environmental science majors, has a more uniform distribution with 42% of enrollment being environmental engineers. EV300, however, has a very diverse enrollment of academic majors with foreign language and foreign area study majors comprising the largest percentage (approximately 16%). Since students are able to select their own term project groups, there is a possibility that a four person group could consist of two or three in the same major, but completely homogenous groups are unlikely and are discouraged.

Collaboration 2: MG380 (Marketing)

The second point of interdisciplinary collaboration occurs between EV300, EV301, and our university's marketing course (MG380). All management majors take MG380 (approximately 70 students each year), as well as a small number of engineering and systems management majors. Occasionally, there are MG380 students that currently are, or have previously been, enrolled in EV300 or EV301 (Table 4); however, while possible, to date no individual has taken both classes concurrently. MG380 employs a semester-long "Green Marketing" project with the purpose of applying marketing concepts to a realistic environmental management problem. Student groups of 3-4 students are first asked to identify and understand the clients' (or "companies") mission objectives, determine the business problem, develop the product and promotion methods, and submit financial impacts. Groups gather marketing research on their target audience and scientific data to back up their marketing claims. As part of this exercise, each group must pitch their marketing plan to the class and the outstanding projects have the opportunity to pitch to clients.

Table 3: Course enrollment in EV301 by student's chosen academic major for the first semester of academic year 2012-2013.

Academic Major	Number Enrolled	Percent of Enrollment
Environmental Engineering	14	42%
Environmental Science	9	27%
Environmental Geography	6	18%
Engineering Management	3	9%
Life Science	1	3%
Total:	33	

Table 4: Course enrollment in EV300 by student's chosen academic major for the first semester of academic year 2012-2013.

Academic Major	Number Enrolled	Percent of Enrollment
Foreign Language & Foreign Area Studies	27	15.6%
Economics	19	11%
Political Science	19	11%
History	17	10%
Psychology, Sociology, Leadership	17	10%
Human and Environmental Geography	14	8%
International & Comparative Legal Studies, American Legal Studies	13	7.5%
Geospatial Information Science	11	6%
Management [a]	11	6%
Chemistry, Life Science, Interdisciplinary Science	12	7%
Defense & Strategic Studies	7	4%
Art, Philosophy, and Literature	4	2%
Environmental Science	2	1%
Total:	173	

[a] Management students are required to take marketing (MG380) as a graduation requirement.

Due to the timing of course offerings, not all EV300 and EV301 student groups have the opportunity to collaborate concurrently. EV300 is only offered in the fall semester; EV301 is offered in both the fall and spring semesters. MG380 is only offered during the spring semester. Therefore, only the spring semester course of EV301 is able to collaborate directly with MG380 during the development and execution of the term projects. However, MG380 students are offered the results of EV300 and EV301 term projects from the first semester, and have the opportunity to discuss findings with the authors directly since the vast majority (>98%) are still enrolled at our university. Likewise, the completed MG380 projects and author contacts are available to the EV300 and EV301 during the following fall semester.

Figure 4 indicates the major collaboration points between MG380 and EV301 students during the spring semester. Student teams from each course operate independently of the other course, but collaborate at key junctures to develop a more holistic solution to a project common to both courses. While possible, the student groups, to date, have not been completely integrated (e.g. 2 students from EV301 partner with 2 students from MG380); we have found that this type of coordination between courses has been too difficult. EV301 and MG380 instructors do not dictate exactly what "collaboration" looks like, but encourage students to conduct face-to-face meetings to discuss how to combine their skill sets to accomplish their common objective. Table 5 shows major milestones and collaboration points for second semester, academic year 2011-2012. While collaboration was not mandatory, students from both classes are required to state how they collaborated with the other class in their final report. Students are also informed that collaboration is taken into account during instructor assessment and project grading. Grading varies between courses. For EV301, collaboration is taken into account when grading the methods and discussion sections of the final term project submission. For MG380, collaboration is taken into account when grading the background and discussion portions of the student's final written submission and oral presentation to their peers.

When project teams from EV300 or EV301 are able to directly collaborate with MG380 project teams, combined student groups are encouraged to brief project results to clients outside of the course together. Ideally, as feasible projects are implemented by clients, feedback is given directly to the EV301 and MG380 instructors. This feedback creates a "need" and establishes the groundwork for future projects during subsequent semesters. In this way a feedback loop is created, and a forum is constantly available to examine emerging energy and environmental problems and market effective solutions at our university (Figure 4).

Table 5: Project milestones and points of collaboration between EV301 and MG380 during the spring semester of academic year 2011-2012.

Lesson	EV301 Requirement	MG380 Marketing Requirement	Student Collaboration
8	Teams pick top 5 project ideas		
17	Project chosen, develop methods	Green Marketing project presented to students	MG380/EV301 share ideas
25	In-progress review		Collaboration window
29		In-progress review: MG380 present what data they plan to use from EV300/301	
31	Data collection review	Marketing Sustainability course lesson	
33		Final In-progress review	
34		Class Presentation/Competition	
35	Submit final report	Winning Groups Pitch to Clients	Students co-present projects
Post Course	As available, students work with clients to implement projects in the local community.		

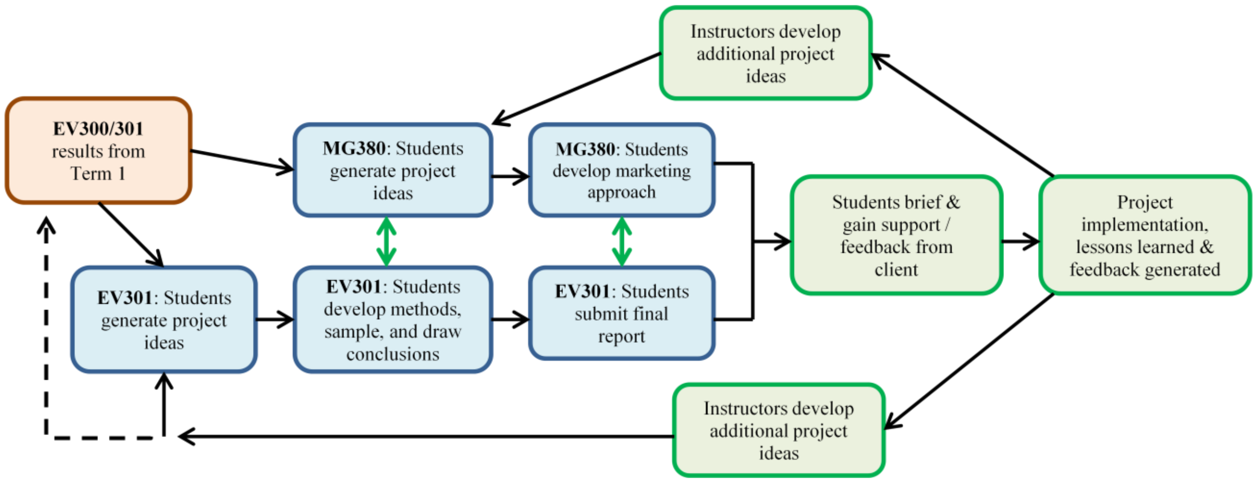

Figure 4: This figure indicates collaboration points between EV300, EV301, and MG380. The brown box indicates actions taken during the first semester (EV300 and EV301 term projects). The blue boxes and green arrows indicate direct coordination between EV301 and MG380 during second semester. The green boxes indicate actions taken after the conclusion of the second semester.

(5) Assessment of Project Implementation and Student Learning

To assess the effectiveness of the term project on student learning, students were asked to anonymously answer six questions using a Likert scale (1-5), and several short answer and demographic questions (Table 6). The same survey was given prior to project inception (lesson 7) and after the final project was submitted (lesson 35).

Table 6: Survey questions posed to students prior to and after the project. Students provided responses on a Likert Scale or in short answer format, as required.

Question 1: I possess the skills to identify, research, and report on an environmental topic/issue in my community.
Question 2: Researching possible solutions to environmental problems in my community is important.
Question 3: The faculty values my data collection, results, and conclusions.
Question 4: Fellow students would value my data collection, results, and conclusions.
Question 5: Working on a community project in class would enhance my motivation and understanding.
Question 6: I value the grade I receive for my project more than the intrinsic value of my work contributing to solving an environmental problem in my community.
Short Answer Question 1: Demographic Questions (gender, student dormitory location).
Short Answer Question 2: What I like most about the term project is: [fill in the blank].
Short Answer Question 3: What I like least about the term project is: [fill in the blank].

Table 7 shows how students who chose a community-based project rated themselves before starting and after completing the term project. As shown, students in each of the three semesters in which the community-based term project was offered in EV300 and EV301 show a significant increase in several areas. Students executing the community-based term project showed a marked increase in their comfort in identifying, researching, and reporting on environmental topics in their community (Question 1). Students also showed an increase in the perceived importance of their results in the community (Question 2) and the valuation of their results (Questions 3 and 4). An increase was also observed in Question 5, indicating that, on average, the community based project was more motivating for the students. The only question in which there was little change between the before and after surveys was Question 6, indicating that this term project did not influence how students perceived their grades versus the intrinsic value of their results.

As shown in Table 8, students who chose the community-based project rated themselves higher than those who chose the general environmental project for almost every question. The difference between the Likert scores for the two projects was not as pronounced in academic year 2012-2013, likely due to the larger number of students participating in the survey and the diversity of topics.

Table 9 shows several example term projects and how they were implemented to date. This table also indicates if students EV301 were able to collaborate with students from the marketing course (MG380), or if students from MG380 were able to use information from previously completed EV300 term projects. Of note, due to student schedules and the timing of the conclusion of the semester, collaborative presentations to clients have been problematic to date.

As indicated in Table 6, students were asked to address what they liked most and least about the term project. While answers varied, most were very positive, and indicated that students found working on a community-based project with a real client was more educationally enriching. Select student comments are listed in Table 9.

Table 7: Improvement in student learning due to participation in the community based project[a]

	Academic Year 2011-2012			Academic Year 2011-2012			Academic Year 2012-2013		
	EV300 Students Surveyed			EV301 Students Surveyed			EV300 Students Surveyed		
	Before (n=29)	After (n=26)	Increase[b]	Before (n=10)	After (n=10)	Increase[b]	Before (n=100)	After (n=82)	Increase[b]
Question 1	3.84	4.52	0.68	4.00	4.60	0.60	3.83	4.05	0.22
Question 2	4.24	4.48	0.24	4.60	4.70	0.10	4.02	4.29	0.27
Question 3	4.16	4.16	0.00	3.40	3.95	0.55	3.6	3.72	0.12
Question 4	3.24	3.59	0.35	3.00	3.50	0.50	2.85	3.29	0.44
Question 5	4.08	4.14	0.06	3.90	4.30	0.40	3.71	3.84	0.13
Question 6	3.60	3.60	0.00	3.05	3.15	0.10	3.59	3.65	0.06

[a]This table shows only the survey results for students participating in the Community-Based Project. Survey results for students participating in the General Environmental Project are not considered.
[b] "Increase" indicates the Likert value (1-5) of the "Before" value subtracted from the "After" value. A positive value indicates an increase.

Table 8: Comparison of Community Based Project to General Environmental Project.

	Academic Year 2011-2012 EV300 Students Surveyed				Academic Year 2012-2013 EV300 Students Surveyed			
	Before (n= 29)[a]	Community Project (After, n=26)	General Project (After, n=40)	Difference[b]	Before (n=100)[c]	Community Project (After, n=82)	General Project (After, n=35)	Difference[b]
Question 1	3.84	4.52	4.15	0.37	3.83	4.05	4.00	0.05
Question 2	4.24	4.48	4.05	0.43	4.02	4.29	3.94	0.35
Question 3	4.16	4.16	3.73	0.43	3.6	3.72	3.71	0.01
Question 4	3.24	3.59	3.15	0.44	2.85	3.29	3.14	0.15
Question 5	4.08	4.14	3.48	0.66	3.71	3.84	3.60	0.24
Question 6	3.60	3.60	3.65	-0.05	3.59	3.65	3.51	0.14

[a]In Academic Year 2011-2012, the "Before" sample population was the same population as the Community-Based Project. A comparison of "Before" and after results for General Environmental Project is, therefore, not valid.
[b] "Difference" indicates the Likert value (1-5) of the General Environmental Project value subtracted from the Community-Based Project value. A positive value indicates the value for the Community-Based Project exceeds the General Environmental Project.
[c]In Academic Year 2012-2013, the "Before" sample population was the general EV300 population. Only 100 students elected to take the survey. After the initial survey, students chose their respective term project topics. Of those who chose a community based project, 82 completed the survey. Of those who completed a general environmental project, 35 completed the survey. Therefore, of the 173 students who took EV300, 56 elected not to participate in the survey.

Table 9: Example projects examined and implemented to date.

Project Description	Client	EV300	EV301	MG380	Implementation
Recycling of non-standard items using the Terracycle program	Student body	X			Decided not to explore Terracycle further due to difficulty coordinating with the program.
Energy usage of appliances in the dormitories	Student body	X			None to-date. Exploring the possibility of mandating energy efficient appliances in dorms.
Analysis of water flowrates from shower heads.	Department of Public Works	X			Department of Public Works is installing low-flow shower heads and sink aerators in all dorms by 2014.
Water conservation campaign – effect on student shower times	Student body; Department of Public Works	X			Several dorms used the posters that were generated during the student study.
Recycling of hangers from student dry cleaning	Laundry facility; Recycling Center	X		X	Our university's recycling center has designed a system to collect and turn-in hangers as scrap metal.
Impact of energy use by computers left-on all night in the dorms.	Student body; Department of Public Works	X		X	Policy regulating computer use in the dorms is pending.
Recycling system analysis in the dorms (multiple projects).	Student body; Recycling Center	X	X	X	The university has allocated > $100,000 in resources to support recycling across campus, largely due to the results of these projects.
Heat loss due to the inefficient heating system in student dorms.	Student body; Department of Public Works		X		Results aided in awareness of the issue at a university level. University is working on a long-term renovation plan, which incorporates more efficient heating.

Table 10. Select student comments concerning the term project and interdisciplinary collaboration.

"We think that collaborating is beneficial and will allow us to pave a way forward to providing a feasible solution…"
"It would be great if I could figure out how to do more projects that count for two classes!"
"The project can be applied to everyday [*student*] life. It is the most applicable and innovative project I have ever done."
"I like the project because the concept of improving the environment here and now - it makes me feel like I can be productive - be a 'mover'"
"It gave us a unique perspective on an environmental issue that was relevant to us..."
"I did not feel like my time spent on my project was a waste of time"
"Project that allows students to be ambitious as they search for ways to help the school"
"Opened my mind to the problems of the world"
"I like the course project because it made one think about his/her own environmental impact as an officer"
"This actually feels like I'm working towards something that's real instead of a canned case"
"Term Project allowed for us to get a better understanding of our impacts on the environment"

(6) Approaches for Implementing this Project at Other Universities

Recommended Project Structure. We recommend four phases to implement this term project and the interdisciplinary collaboration model at other universities:

1. Partnership
2. Topic Development
3. Implementation
4. Evaluation, Feedback, and Revisions

Our university's current term project model aims for students to identify a localized environmental problem, obtain relevant data, and support a conclusion with generalized recommendations. At the same time, marketing students use the data and generalized conclusions to produce a marketable campaign or promotion scheme in order to effect change in the hopes of reducing the originally identified environmental problem. The partnership phase of the term project model should be structured around this general construct; however, more ideal relationships may exist in other universities. Additional courses, such as business or fine arts courses, which target different populations of students, resources, or university educational objectives, may also be available for collaboration. These types of courses may still fit within the current model of promoting environmental change while making the presented model more effective.

The topic development phase (see Section 2, Step 2) will depend on current conditions and available clients or stakeholders at each respective university. Topics could potentially include air, noise, energy, water, wastewater, and solid waste based focus areas. Available resources, such as equipment or laboratory space, will likely narrow the list of potential topics. Each university or community will offer various client organizations that provide different but exciting opportunities for environmental research. Partnerships with these client organizations must be cultivated in the hopes they provide a continual source of project interests for future research. The opportunity for a client organization to receive annual feedback, recommendations, and a free campaign or promotion idea may be enough to generate interest.

Within the implementation phase (see Section 2, Step 4), we feel that parallel execution of the introductory environmental engineering and science course and the partnered course offered in the same semester is likely the best way to structure this term project model. By conducting parallel execution, student teams from both courses will be able to maximize real-time collaboration and potentially produce a higher quality final product as a result. If academic and schedule freedom allows, we recommend specific alterations to the current model. Co-teaching of a lesson on proper collaboration methods can occur to help develop a relationship between the two paired student teams. This lecture could be presented immediately after the marketing or business-related student teams select the environmental project with which they wish to work. In-progress reviews with each instructor could also be extremely beneficial, as students would receive two different perspectives on their collaborative efforts. In addition to the submission of a final written report, efforts to conduct a joint presentation to the client could occur prior to the end of the course with both teams presenting their respective pieces of the final recommendation and solution to the initial environmental problem.

Faculty time requirements. The majority of an instructor's time commitment will likely occur when establishing collaborative partnerships. Time will be required to identify courses and associated instructors with whom to partner and coordination to synchronize courses will be required. The alignment of course goals, objectives, and syllabi could present a significant time commitment. Time will also be required to realign basic course administrative tools and products, as well as the development or refinement of the term project evaluation and feedback measures. During topic development, term project clients need to be identified and initial project scopes outlined. For undergraduate courses in particular, due to time constraints, instructors will likely need to develop potential clients prior to beginning the project. Additionally, co-teaching, if desired, to help promote teamwork and collaboration must also be developed and prepared.[3] Lab managers may be able to assist in distributing equipment and instructing students on operational procedures. Once an initial model is established, faculty time requirements may lessen; however, built-in feedback loops, which may be time intensive, will be required for successful long-term implementation of student projects.

Required resources. Students in an introductory environmental engineering program will typically have minimal laboratory experience or this term project may be their first foray into a STEM-related research project that requires the collection and analysis of scientific data. As such, it is recommended that the program have basic laboratory facilities available with the capability to conduct basic water and wastewater quality testing, noise testing, air quality sampling, and energy monitoring (Table 11).

Table 11. Equipment listed by project topic that would provide baseline capabilities for fulfillment of the term project requirements.

Equipment	Project Topic	Equipment	Project Topic
Radon Meter	Air	Colorimeter	Water
Particulate Matter Meter	Air	pH Meter	Water
Sound Meter	Noise	Turbidity Meter	Water
Solarimeter	Energy	Dissolved Oxygen Meter	Water
Kill-a-Watt	Energy	TDS / Conductivity Meter	Water
Wind Speed Sensor	Energy	Automatic Composter	Waste
HOBO Data Logger System	Various		

This term project model can be applied to universities with extensive laboratory facilities and available tools, as well as those universities with very few resources or available space. If there is very little available bench space in the laboratories, it may not be feasible for student projects which focus on water related topics. Rather, it may be more advantageous for those student teams to research energy or noise problems where data can be taken on site and then manipulated and analyzed on a personal computer. In this way, instructors are able to manage the overall space and instrument/tool requirements by only allowing term projects in specific focus areas.

(7) Conclusion

Many universities have real environmental problems but do not always have the time or resources to examine the problems. Well designed student projects can assist clients examine these problems, help the community, and enhance student learning. Our university employs an introductory environmental engineering and science course taken by environmental engineering and science majors and many non-STEM majors, which accomplishes this goal. The EV300 and EV301 term project that examines real environmental problems, by requiring student teams to develop a hypothesis, a basic sampling, and evaluation protocol. Students then use the protocol to conduct sampling in the local community and analyze results in light of their hypothesis. To assist in meeting ABET criteria, EV301 has integrated an additional engineering design component to the project to assist in meeting ABET criteria. The presented term project model also encourages interdisciplinary collaboration in two ways: within term project groups, and through collaboration with our university's marketing course. This educational method can create more holistic solutions to the identified problems and enhance student learning. Additionally, this project can realistically be implemented at other universities.

References

1. ABET Engineering Accreditation Commission, 2010. "Criteria for Accrediting Engineering Programs: Effective for Evaluations during the 2011-2012 Accreditation Cycle".
2. Alden, S. D., Laxton, R., Patzer, G.L., Howard, L., 1991. "Establishing cross-disciplinary marketing education." *Journal of Marketing Education*, 13:25-30.
3. Ambrose, S.A. and C.H. Amon. 1997. Systematic Design of a First-Year Mechanical Engineering Course at Carnegie Mellon University. *Journal of Engineering Education*. April. 173-181.
4. Bates College, Department of Biology. "The Structure, Format, Content, and Style of a Journal-Style Scientific Paper". Available from: http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWsections.html. Accessed: 12 December 2011.
5. Bates College, Department of Biology. "*Almost* Everything You Wanted to Know About Making Tables and Figures". Available from: http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWtablefigs.html. Accessed: 12 December 2011.
6. Booth, S., Barnett, J., Burman, K., Hambrick, J., & Westby, R. (August 2010). *Net Zero Energy Military Installations: A Guide to Assessment and Planning.* Oak Ridge, TN: National Renewable Energy Laboratory.
7. Botkin, D. B., Keller, E. A. 2011. Environmental Science: Earth as a Living Planet, Custom Edition, 8th Ed. John Wiley & Sons, Hoboken, NJ.
8. Bridges, C. M., and Wilhelm, W. B., 2008. "Going Beyond Green: The 'Why and How' of Integrating Sustainability Into the Marketing Curriculum". *Journal of Marketing Education*, 30:33-46.
9. Carlson, L, and Sullivan, J, 1999. "Hands-on Engineering: Learning by Doing the Integrated Teaching and Learning Program". *International Journal of Engineering Education*, 15, 1:20-31.
10. Coyle, E., Jamieson, L., Oakes, W., 2006. "Integrating Engineering Education and Community Service: Themes for the Future of Engineering Education". *Journal of Engineering Education*, 95, 1:7-11.
11. Hammervoll, T., 2011. "Managing interaction for learning and value creation in exchange relationships". *Journal of Business Research*, 65, 2:128-136.
12. Hungerford, H, and Volk, T., 1990. "Changing Learner Behavior through Environmental Education". *Journal of Environmental Education*, 21, 3:8-21.
13. McKeage, K, Skinner, D, Seymour, R.M., Donahue, D.W., Christensen, T., 1999. "Implementing an Interdisciplinary Marketing/Engineering Course Project: Project Format, Preliminary Evaluation, and Critical Factor Review". *Journal of Marketing Education*, 21, 3:217-231.
14. Mills, J, and Treagust, D., 2003. "Engineering Education – is Problem-based or Project-based Learning the Answer?". *Australasian Journal of Engineering Education*. Available from: http://www.aaee.com.au/journal/2003/mills_treagust03.pdf