AC 2007-2595: STUDENT PRODUCED CASE STUDIES IN AN INTRODUCTION TO ENVIRONMENTAL ENGINEERING UNDERGRADUATE COURSE TO CREATE AN INTEGRATED CONTEXT FOR THE COURSE CONTENT.

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Student Produced Case Studies in an Introduction to Environmental Engineering Undergraduate Course to Create an Integrated Context for the Course Content.

Introduction

The creation of a student developed case study of an industry, business or municipality and its environmental challenges has allowed undergraduate students to apply and understand the course content material in an integrated manner. This is a sophomore level engineering course which introduces engineering technologies for control of the environment, and relates them to underlying scientific principles. Cases from aquatic, terrestrial and atmospheric environments are discussed. The students also get an introduction to some of the major environmental laws. This is mostly a survey course with some elements of engineering design in environmental systems. The breadth of the topics can lead to student perception of unrelated items in a textbook. Even when problems are based as real life examples, the students appear to have difficulty understanding that the course material is all interrelated and can be applied to complex environmental problems. To relieve the sense of remoteness from the content material students create a case study of an industry throughout the semester.

The Case Method

Cases are usually narratives which are an "account of an engineering activity, event or problem containing some background and complexities actually encountered by an engineer."[1] Cases can be presented in a variety of formats such as case histories or problems. A case history is an account of an actual event or situation, warts and all. A case problem is an open ended situation with many possible solutions.[2] Richards and Gorman[2] describe the development of cases as a four step process with at least four stages. These stages are: Problem identification; investigation, interviewing, and information gathering; case development and use; and evaluation and refinement.

The use of cases in engineering education has been reviewed by Richards et al. [3] They describe the use of well prepared case studies as providing students with relevance, motivation, active involvement, consolidation/integration and transfer. The students gain relevance through problems and solutions that practicing engineers encounter. Motivation and active involvement occur through the complexity of the cases providing interest creating incentives for the students to immerse themselves in the topic. The students are active learners through participation, discussion and resolution of the case. The need to draw upon a variety of knowledge sources and integrate concepts leads to integration and consolidation. Through development of case-based reasoning, students can use the knowledge and skill acquired during the case method to transfer to new experience by drawing on the experiences they developed during their case study, or as discussed in this paper, the development of a case. Richards et al.[3] also describe that the use of cases works best when they are extensively used during the semester. Bhandari and Erickson[4] make the point for the need of using case studies to prepare environmental engineers for the workforce. For these reasons and the need to give the students ownership of the knowledge, an attempt to foster learning through student developed case studies was undertaken.

Pre-developed or faculty derived case studies to improve science and engineering education have been well documented and a number of texts, centers and university websites exist as sources of such material [5,6,7,8,9]. These websites also contain a number of resources for the development of case studies and student assessment. However, the use of student developed case studies is less utilized. The author is proposing the integration of a student derived case study throughout the course material to enhance student learning.

Structure of the Course and Integration of the Student Developed Case

The Introduction to Environmental Engineering Course is taken predominately by students in an engineering science degree with a concentration in structural civil engineering. The engineering program at the University is small and courses tend to have a low student to teacher ratio, with the instructor for a course frequently remaining the same from year to year. The students in the course can be in their sophomore to senior year.

The course is a survey course with calculus and a semester of chemistry as the prerequisites. The outline of the lecture style course is as follows:

1. 2.5 weeks on chemistry
2. 2 weeks on physical processes
3. 2 weeks on biology
4. 2 weeks on water pollution
5. 1 week air pollution
6. 1 week solid waste
7. 1 week hazardous waste and risk assessment

All topics are covered in an introductory manner with a broad subject base. The chemistry, physical processes and biology all involve the use of relevant environmental system examples to teach the basic concepts. The chemistry portion covers units of concentration, activity, kinetics, thermodynamics, equilibrium, carbonate system, precipitation, sorption, oxidation and reduction. The students tend to have a better conceptual understanding of the physical processes. This mainly involves mass balance, mass transport processes and flow through porous media. The students have the least experience with biology. The coverage is on ecosystems, population dynamics, energy flow in ecosystems, biochemical oxygen demand and the effect on rivers, material flow in ecosystems, public welfare, microbes, etc. The second half of the course a survey of the problems, types of pollution, laws, measurement and treatment and design of pollution in water, air and land. Solid waste, hazardous waste, pollution prevention and risk assessment are also briefly studied.

In the past students have done a poster presentation on a problem such as desalinization or nitrogen removal from water. The students selected a topic, researched the different treatment options, developed criteria to evaluate the options and selected their final solution based on their criteria. The poster was presented at the end of the semester and did not correlate well with the topics covered in the entire class. The students seemed to find the whole first part of the course unrelated to engineering. To get the students to understand the complexity involved in environmental engineering especially related to designing or selecting a treatment system a directed project was developed which asks student to answering leading question which relate to current course content, in the pursuit of developing a case study of an industry, business or municipality. The students do not fully develop a written case study. They identify a problem, investigate and gather information and begin to evaluate and develop their cases for presentation at the end of the semester.

The students meet for a few minutes in class to discuss potential industries to use for their case study. They then research these industries and select one and submit it to the professor for approval. A scaffold of activities related to the content covered in lecture is used to guide them through the process. These activities are submitted as progress reports through out the semester. Table 1 is a guideline of the leading questions, what topic has been covered and when they would be submitted as progress reports. This information is provided to the students at the beginning of the semester as part of the syllabus.

Table 1

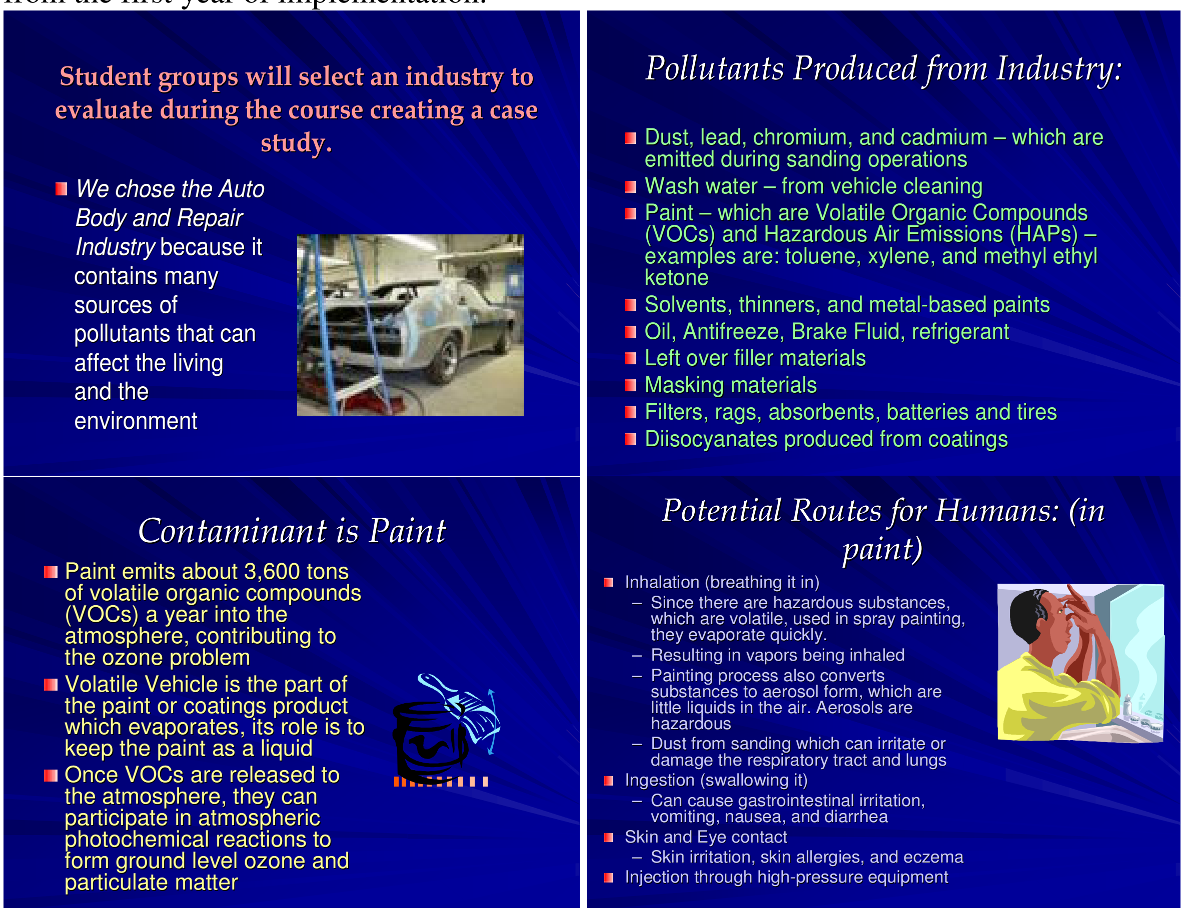
Lecture topic covered	Group or individual Week due	Questions for the progress report
Introduction to course	Group 2nd week	Select an industry to evaluate during the course to create a case study
Chemistry	Individual 4th week	Identify the pollutants produced from the selected industry? What are the Chemical, physical, biological characteristics of the major pollutants? What is the source in the industrial process? In to what media (air, water, and land) is the pollutant discharged?
Physical processes and half of biology	Individual* 7th week	Identify the major transformation and transport processes which may involve your contaminants (is it biodegradable, volatile,…). How would you model or quantify these processes? What information do you need to model and quantify these processes? For one of the contaminants determine a simple model for fate and transformation.
Biology	Individual 9th week	Identify the potential routes of exposure to humans, plant and animals for the contaminants you have selected in your industry. What are the health effects associated with these contaminants? Are they concentration dependent?
Water pollution	Individual 10th week	Identify the major discharge regulations for your industry. Are your selected contaminants before treatment above or below the regulated levels?
Air Pollution	Group 11th week	What types of treatment systems are needed? Describe the major alternative systems for removal of the contaminant. Select the type of unit to treat the contaminant. Include your rationale and criteria for the decision on the unit selected (you can include cost and ease of operation as criteria).

Solid Waste	Group 12th week	How is your treatment system designed? What information is needed? What are your constraints? Size your unit(s). Can you redesign the industrial process to eliminate the waste? How?
All topics	Group 13th week	Prepare the presentation

* Except for the development of a simple model

The students present their case study to the class at the end of the semester. After each presentation the students discuss what they learned during this process. The following is an example of a portion of a final student presentation.

Figure 1: These slides represent some of the information a student group collected for their case study. This group of students looked at the auto body and repair industry. This presentation was from the first year of implementation.



Feedback

This project has been implemented for two years (2005, 2006) in a small class of predominately structural civil engineering students. In the first year all work was submitted as a group effort and groups were as large as four people. This did not work well since some students did not participate to the fullest extent. In the next year, the first few progress reports are shared in class and submitted individually. The last few progress reports are done as a group and the students can then select one contaminant to study. The student also worked in pairs instead of larger groups (partially due to a small class size). Students appear to use the internet to a great deal to find the information and a couple of the students have actually interviewed a practicing engineer as well. In both years most students had a difficult time completing the 12th week assignment. A portion of the lecture time was required for students to ask questions and meet briefly in their groups. Industries that have been selected have been photographic, construction as related to non point source pollution, automotive painting and silk screening in a plastic dishware industry.

Feedback information has been gathered through the traditional course and teacher evaluations administered by the University. The students are asked a set of question in all classes with at least six students. The questions are grouped into 4 major categories these are: (1) Overall evaluation of instructor and course (8 questions); (2) Workload/Difficulty (4 questions); (3) Grading/Feedback Quality (4 questions); and (4) Interaction and encouragement for instructor to student (2 questions). The responses are on a 5 point scale with 1 having the following meanings-outstanding, clear, always, too fast or difficult and a 5 meaning-below average, unclear, never, too slow or easy. The optimal score for categories 1, 3, and 4 is a one and the optimal score for category 2 is considered a 3. The scores for the categories are summarized in Table 2. The number of students in the course varied from 6 to 9 for the years discussed.

Table 2

Categories	2006	2005	Mean 2005 and 2006 (n=2)	S N=2	90% confidence interval of the mean n=2	Mean 2000 to 2004 (n=3)	S n=3	90% confidence interval of the mean n=3
Overall evaluation of instructor and course	1.4	1.6	1.5	0.14	0.62	1.8	0.21	0.35
Workload/Difficulty	3.2	2.4	2.8	0.56	2.5	2.6	0.21	0.35
Grading/Feedback	1.1	1.6	1.35	0.35	1.56	1.6	0.20	0.35
Interaction and encouragement	1.2	1.3	1.25	0.07	0.31	1.5	0.12	0.20

S-standard deviation

The same instructor gave the course in the years summarized. The student developed case study was added in 2005 and continued in 2006. The overall evaluation of the course and teacher improved from an average 1.8 to an average of 1.5, though this difference may not be significant. The students seemed to perceive a slight decrease in the workload. The course expectations of homework and exams did not significantly change through the years. Students appeared to find better feedback in the last year of the implemented project. The average for interaction and encouragement decreased from a 1.5 to a 1.25 after the case study was added indicating the students had better communication with the instructor. The small class size may make these values unreliable. Theses results are not statistically significant because of the small sample size due to the number of times the course has been taught after the case study was added.

Conclusion

The project requires students to use the skills and tools acquired through the class to analyze a real life situation. The students identify, evaluate and critically compare information to make decisions on the appropriate means to deal with the release of one or more contaminants to the environment. Students analyze potential treatment options, (including pollution prevention) identify major laws and use the engineering design process to make decisions on their final solution. This process improves and requires critical thinking, problem solving and utilization of the engineering design process. The feedback from the course and teacher ratings, which are not designed to test the effectiveness of the student developed case study, indicated a positive impact of the student impression of the course. The course and teacher received better ratings and students thought there was better feedback and encouragement in the class.

The Future

The initial response and attempt at implementing a student developed case study has been positive. Several aspects of this method need improvement. The students should include a final written report in a format consistent with a case study. A better method of assessing the student performance in the groups should be developed. The development of an analysis of the decision making process during case development needs to be included. For example how they decided what the major contaminants were and what the criteria for evaluation was for the industry were important processes and should be documented. A method of assessing the effectiveness of the case study on student learning needs to be developed for this course. The general course in teacher ratings did not provide an informative assessment of the impact of this project on the student learning using a self derived case study. The course is currently being taught this spring and an evaluation at the end of the case study will be utilized as well as some reflection questions.

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http://www.civeng.carleton.ca/ECL/about.html
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http://www.mtholyoke.edu/acad/programs/wcl/casemethod/index.shtml

9. The Harriet L. and Paul M. Weissman Center for Leadership and the Liberal Arts, Mount Holyoke College. 50 College Street South Hadley, MA 01075-6427 http://www.mtholyoke.edu/acad/programs/wcl/casemethod/resources.shtml