"Hyper-Active Learning" in an Upper Level Engineering Classroom

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Introduction

During the Spring 2001 semester, I "abandoned" the use of traditional lectures in CE433 (Solid and Hazardous Waste Engineering), and instead required students to fill out worksheets during class time. This class contained 15 students. The students were mostly juniors and seniors and were either environmental engineering majors or civil engineering majors with an environmental engineering emphasis.

This project was initiated as an effort to solve the following problems:

1. I have found that students do very little of the assigned readings in upper level courses. Perhaps I may perpetuate this problem by supplying the students with all the necessary information in lecture!
2. I prefer to use lectures to discuss concepts rather than define vocabulary, explain the intricacies of regulatory rules, list out code requirements, etc. However, I cannot lecture on concepts if students don't understand these basics.
3. Although my lecture skills have been highly rated by students and they appreciate my enthusiasm and the active nature of my lectures, I still note that many students are not engaged in the lecture.
4. Another problem I view with lectures is that students can gain a certain amount of confidence and familiarity with the material, and mistake this superficial learning as the same as deep understanding.

Worksheet Procedure

The basis of solving the above problems was to require students to fill in worksheets during the class period. One worksheet was designed for each class period, and was typically two pages long. The worksheets were based on my previous lecture notes for the course. Thus, nearly every topic covered previously in lecture was covered on the worksheets. Students were instructed that if they filled out the worksheets carefully, the result would be a complete version of the notes, with my questions serving as the outline.

For this technique to be successful, I realized that students would need to do the reading; otherwise, lecture time would not be productive. Therefore, frequent reading quizzes were administered. These quizzes were not intended to assess understanding of the concepts, but rather to simply check whether students had read the required material.

I intended that the majority of each worksheet could be completed in class. Students worked in teams of three to complete the worksheet, and typically were able to complete approximately 75% of the worksheet in class. The remainder was completed as homework. I found it effective to stop the students when most of them were done with the first page, and summarize and discuss that material.

Sample worksheets are shown in the Appendix.

Assessment

My assessment of this project is based on student evaluations, my own observations, and feedback from my Student Management Team. A Student Management Team is a group of three or four students who interact with the other students and work along with the professor to guide the course. Students have a managerial role, and assume responsibility for the success of the class[1]. I have used these teams previously, and they are an excellent means of obtaining feedback from those students who would otherwise save their assessment for the end-of-the-semester course evaluation. They work especially well when teaching a course for the first time, or when incorporating an innovative or somewhat radical approach into a course as I did with this study.

I was very happy over all with the worksheet approach. The vast majority of the students had completed their required reading. Students were definitely engaged for the entire class time. Indeed, in groups of three, they had no chance to "hide" or not contribute.

I also noted that when completing the worksheets in class, students did not always work collaboratively. Rather, students would split up the work such that each student worked independently on his or her assigned problems.

The reading quizzes, although valuable in compelling students to read, used up a large amount of class time. Also, creating a fair but effective quiz was difficult. Questions couldn't be too difficult, since students can't be required to master the material on their own; if this were possible, instructors would not be necessary. On the other hand, the questions can't be so simple that students can easily guess at the answer or answer them based on previous knowledge.

The response from students, both through the Student Management Team and through course evaluations, were mixed. Indeed, several students simply felt that they learned more from sitting through a traditional lecture than from filling out worksheets. Although traditional lecturing is certainly effective for certain types of learning styles, I feel that some of the negative responses were due to the fact that students could no longer sit inactive for the class period, and had been forced from their "comfort zone."

The worksheets focused on definitions and concepts, and did not contain many quantitative problems. Several students mentioned that they would have rather had more of these types of problems to solve. This may be interpreted as a reluctance to delve deep into the more open-ended conceptual problems, or rather a fundamental need for engineers to solve problems to feel that they have mastered the material.

Perhaps the most common complaint voiced by students is that they felt that they needed an introduction to the topic. They felt like they were being forced to solve problems and understand concepts without being aware of where these concepts fit into the "big picture."

Planned Modifications

I have planned the following modifications, to be incorporated during the Spring 2002 semester.

1. Quizzing students on the reading will be replaced by requiring students to turn in outlines of the reading prior to class.
2. Each lecture will begin with a summary of any graded worksheet that was handed back to the students in that class period.
3. Following this review, a brief introduction will be given for the day's topic, such that students are made aware of where the topic fits into the "big picture."
4. Each group will hand in a single word-processed worksheet.
5. Students will be provided with more quantitative problems, perhaps in homework form, that will be handed in individually rather than in a group.

Conclusions

The use of worksheets can be a very rewarding and effective use of class time. Students are forced to be active, learn to work collaboratively, and are forced to think in class rather than merely sit and take notes. Such an approach forces many students from their "comfort zone," but with carefully constructed worksheets, I feel that this technique is very effective.

Bibliography

1. Nuhfer, E.B. "A Handbook for Student Management Teams," a report published by the Teaching Excellence Center, University of Wisconsin-Platteville and the Office of Teaching Effectiveness, University of Colorado at Denver.

Biographical Information

PHILIP PARKER
Philip J. Parker is an Assistant Professor of Civil and Environmental Engineering at the University of Wisconsin-Platteville. Dr. Parker received his B.S., M.S., and Ph.D. degrees from Clarkson University in Potsdam, NY. His research interests include water treatment, solid waste management, engineering education topics such as inquiry-based learning, and Writing Across the Curriculum. His e-mail address is *parkerp@uwplatt.edu*.

Appendix

Sample Worksheets

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Lesson #11 Worksheet Module 2

YOUR NAME:___________________________

1. Please fill in the following table.

Comparing Risk Assessments for Carcinogens and Non-Carcinogens		
	Carcinogen	**Non-Carcinogen**
Dose/Response Curve		
Characteristic of toxicity		$RfD = \frac{NOAEL}{\text{Uncertainty factors}}$
Quantity of contaminant	CDI is the average daily dose of a chemical over the lifetime of an individual, normalized for his or her body weight.	
Risk?	Risk > 0 for all doses	
Quantifying Risk	Risk =	Hazard quotient = Hazard Index =

2. The average ambient air concentration of carbon tetrachloride in an urban region is approximately 1.2 $\mu g/m^3$ of air. What is the ADD (average daily dose), expressed in mg/kg-day, received by an average adult, assuming that all the inhaled contaminant is taken up by the body?

3. An industrial facility emits formaldehyde into the atmosphere with a peak concentration in the surrounding community of 4.6 µg/m^3. What is the lifetime cancer risk to a maximally exposed individual?

4. The industrial facility assessed in problem #3 is located in the community of Gut Gulch. If Gut Gulch contains 30,000 people, estimate the total number of expected additional cancers per year from inhalation of formaldehyde. How does this incremental risk compare to the number of cancer deaths expected in Gut Gulch under "normal" conditions (i.e. if the industrial facility did not emit formaldehyde). Note that your lifetime chance of dying from cancer is roughly 1/4. However, this is not a yearly rate. To arrive at a yearly rate, you can use this information: in 1988, there were 2.1 million deaths in the U.S., 480,000 of those were from cancer, and the U.S. population was 245 million people.

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Lesson #17 Worksheet   Module 4

YOUR NAME:__________________________

1. a) How is Henry's constant related to volatility? Answer quantitatively and qualitatively.
   b) Which has a higher Henry's constant: gasoline or water?
   c) What does equilibrium have to do with Henry's Law?

2. There are at least two choices for units on Henry's constant. *This can easily be confusing!* What are two typical units for Henry's constant?

3. From Appendix A, list three of your favorite chemicals and their Henry's constant.

4. In your own words, what does the diffusion coefficient have to do with air stripping?

5. What is a typical value for Henry's constant, below which volatiles are not conducive to removal via air stripping?

6. Your text states that "values of this factor (R) must be greater than one for stripping to occur." Explain this statement.

7. What is a typical range of design values for the stripping factor?

8. At first glance, equation 13.22 in the Coursepack appears to be at odds with the definition of stripping factors on p. 449 in your Hazardous Waste Management text. Reconcile these two definitions.

9. What is the value of the stripping factor if you assume 100% removal and that the gas and liquid phase are in equilibrium?

10. In your own words, explain how the Q_a/Q_w ratio will affect removal.