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Environmental Engineering Laboratory Development to Promote Active and Hands-On Learning

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Extended Abstract - Environmental Engineering Laboratory Development to Promote Active and Hands-on Learning

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***Abstract* – This extended abstract details one instructor's experience in incorporating hands-on laboratory portion in a junior level civil engineering class, Environmental Engineering. The objective of the change was to help students become more involved and aware of their own learning through active participation so that they can relate to course contents in a better way. The author sought to achieve this through a laboratory structure that 1) required students to reflect on certain topics and device a do-it-yourself experiment to measure certain parameters and 2) provided a level of autonomy by allowing them to choose to work alone or in small groups. The author implemented changes over a period of couple of years and made changes in types of laboratory experiments to suit course contents as well as to promote active and hands-on learning. Students' participation in various types of labs made the course more interesting and students showed better involvement in class discussion. Instructor reflections and conclusions are included.**

Index Terms – autonomy, hands-on, laboratory, active, do-it-yourself

HISTORY AND INTRODUCTION

CVEN 314, Environmental Engineering, is a junior-level course in civil engineering and is the only required course focused on environmental engineering that students must take before they graduate. This course is designed to introduce students to the discipline of environmental engineering, its breadth, concepts and terminology required for environmental engineering practice. Students are introduced to the theory of unit operations and processes most often used in environmental engineering, water purification and wastewater treatment. Additionally, students learn to use the knowledge of mass-balance, chemistry and biology to model bio-chemical oxygen demand and degradation of oxygen demanding waste in a river system. Also, it increases awareness of environmental considerations in civil engineering projects. Students also learn fundamentals of air pollution, sound pollution and related issues. I have been the primary instructor of the course since spring quarter of 2012-13.

The course officially is listed as 3-2-3 (credit hours – lecture hours – lab hours) in the university catalog. First two years the laboratory hours were used as additional in-class contact hours for work-out problems, solved examples, educational videos, visits to water and wastewater plants instead of laboratory experiments. In the past, every time I talked to students about measurement of various water and wastewater related parameters they seemed to understand it well. However, many of them expressed a clear desire that this section of the course could be more interesting. On a ten-week quarter system, often there is not enough time for an instructor to cover enough video sessions, treatment plant visits, and term-end group presentations by the students in addition to help-sessions to go over solved examples and work-out problems. The pace of the course is fast and if students are not involved and active from the get go they usually fall behind and it results in poor grades.

Since my first day at Louisiana Tech, I was constantly working on putting together a teaching laboratory for this course. In winter quarter of 2015, I started to make changes to incorporate laboratory portion by introducing measurement of various parameters related to water pollution such as bio-chemical oxygen demand, pH, and conductivity. In the winter quarter of 2015-16, the author expanded lab activities by introducing measurement of noise levels, salinity, and total solids (total suspended solids and total dissolved solids). It includes a do-it-yourself activity that allows students to choose a place and design their experiment for noise level measurements and compare them with standard/recommended values by the Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA). Students are asked to submit a formal report based on their measurements that they perform. In their reports, students are asked to provide background and the theory related to the measured parameters. Each report is prepared by a team of maximum two students. I hoped that it would be more hands-on than just watching related videos and learn from them. Also, I wanted students to spend their time learning, discussing and doing hands-on activities, not searching online videos for measurement techniques. I hoped that submission of a formal report complete with pictures of experiment setup taken during demonstration/measurements along with pictures of rough laboratory notes would demand greater student involvement. I weighed upon positives and negatives of up to two students per report. What if there were free loaders? Or they took turns for lab reports?

IMPLEMENTATION

Studies have shown that when students are put in a formal hands-on and active teaching environment requiring more involvement on their part they learn better [1]-[5]. They tend to retain information longer that they gained during active and hands-on learning sessions. This results in better academic performance. I think bombarding students with lots of information in the form of a class lecture is not an efficient way of teaching. Students tend to get passive and often suffer with information overload without much processing time. I felt this was the case in my class despite my best efforts to include video sessions and various kinds of quizzes that included a combination of participation, completion and performance based evaluation methods.

I realized that covering all the course contents in a fast-paced ten-week quarter system doesn't leave much room for processing time if careful planning is not done in advance. I started with four laboratory exercises that involved measurement of basic water quality parameters in the first year of laboratory development and inclusion in the course. Students were shown demonstrations of the measurements in each lab session. A questions and answer session followed each demonstration and then students were asked to take turns in a group or as individuals to collect their own data by measuring the parameters using the demonstrated technique. Experiments were chosen based on relevance of lecture topic being discussed in the class, availability of equipment, associated costs, level of difficulty in learning the technique in one session, time required to complete the measurement in a lab session and the level of effort needed for students as well as instructor.

Students then used their own collected data to plot graphs and perform standard mathematical analysis. A formal technical report was to be submitted by each group/individual via Turnitin feature available on course management system, Moodle, within a week of the laboratory session. The basic components and the format of the report were shared with students at the start of the quarter. The grading rubric was also provided ahead of time. Students were given detailed instructions about the report requirements in the course laboratory manual. One of the instructions was to include pictures of experimental setups and measuring devices taken during their own measurements. Also, students were asked to include pictures of their rough calculations and notes taken during laboratory session as appendices of the report. The laboratory manual was intentionally kept concise (about 7 pages) and very simple for students to be able to read it completely so that they do not skip portions of it. It was divided in to three main sections that focused on student activities before, during and after each session. Section one "Before Each Lab" covers things and activities each student is supposed to focus on. The information in this section was broken in to four different sub-sections that are What, When, Who and What If. The sub-section "What" specifically directs students' attention to one or a combination of things listed below.

- A document to read (and understand)
- A list of supplies to bring
- The URL of a website to visit
- A link to a video introduction/tutorial for the lab

The sub-section "When" provides information about the time-line of availability of these resources on Moodle. The sub-section of "Who" specifies that "Although most lab exercises will involve working in groups, each student is required to prepare in fullness for each lab. The lab instructor reserves the right to begin any lab with a short quiz on the material posted on Moodle. Such a quiz would be included in the individual lab grade of the student, rather than for the lab grade of the group." The "What If" section covers situations where a student cannot access posted resources prior to attending a lab session and suggests course of action for students to take.

The second section "During Each Lab" of the manual is less than one page and covers expectations from students while they are in the lab. There are some instructions and pointers for students to follow to keep them safe and their work stations clean. The remaining portion provides information report format, appropriate way of presenting the collected data in a plot, accepted ways to cite references and needed safety information. A detailed grading rubric adopted for laboratory reports is presented in Table - 1. Students' feedback was positive and they really enjoyed hands-on activity part. Some students didn't like the formal report writing part of the lab portion. However, many students expressed that it was very useful and it made them better at writing a technical report. In the winter quarter of 2015-2016 academic year, I made further changes to the lab portion of the course. In one of the changes, I brought a DVD to the class and played a documentary by History Channel titled Modern Marvels: Sewers. Students were asked to write a one-page critical review afterwards and submit it via Turnitin link provided on Moodle. Students really liked it. I made another change this year. A do-it-yourself lab was added to the curriculum. This lab gave students freedom to design their experiment to measure noise levels in a setting (indoor or outdoor) using a given sound meter and compare them to standard values recommended by the EPA and OSHA. The students were given the sound meters and were given one week to complete this assignment and submit their reports. This was one of their favorite labs this quarter. It gave them freedom to design their own experiments based on what they were trying to accomplish. Instructor provided feedback as needed and highlighted plus and minus points of each experiment design. Next year, the author plans to include a session where each group/individual will be asked to share their experiments with rest of the class.

TABLE I
GRADING RUBRIC FOR LAB REPORTS

Title Page (2.5 pts)	The title page must show the number and title of the experiment or assignment, the date performed, your name, and your partner's names from the data collection component (if any).
Table of Contents (2.5 pts)	Each page of the report must be numbered and included in the Table of Contents.
Objective (5 pts)	In 50 words or less, make a good overview statement regarding the objective of your experiment. A properly done objective can be as short as one sentence but must relate to everything included in the report.
Background and Theory (25 pts)	This section should present all of the relevant equations used and illuminate their development from base governing relationships as is often done in textbooks. Be sure this development makes sense to you as you include it. It is easy to simply "accept" the equations we use in engineering without asking the question "why?" By engaging in their development, we can begin to see the relationships that exist throughout the study of engineering and (more importantly) the much larger world that they attempt to describe and predict.
Procedure (20 pts)	This section should include a neat schematic of the setup (if any) or situation investigated. All equipment used should be identified and details should be included that reference the manufacturer and model number where appropriate. Illustrate and describe the function of each piece for clarity. Outline each step taken while performing the experiment so it can be duplicated simply by reading your report. As you step through this procedure, reference the equations you developed and set the stage for the Results section. Do not simply restate or copy the lab handouts into this section (or any other). This section should show original thought and your personal description of the procedure.
Results (15 pts)	This section should contain formal presentation of the experimental results using tables, graphs, etc. Keep this section relatively simple. Reference the steps you laid out in the Procedure section and give the result for each step. No need for analysis and discussion in this section. With that said, however, do not simply include results with no textual support that describes what the result is. For example, a plot with no description of what it shows, or what part of the experiment it is from, is useless.
Discussion and Conclusions (20 pts)	This section interprets the Results and explains how the objective of the experiment was accomplished. If there is known experimental error, include it here. Comment on the strengths and weaknesses of your work or the experiment as they relate to the original objective. Make recommendations on how the results might be strengthened. The actual scoring breakdown for this section totals 20 pts as follows: 5 pts for general comments on how the objective was achieved, 10 pts for comments on errors, strengths, weaknesses, and recommendations, 5 pts for additional discussion questions
Appendices (5 pts)	Original Data - fully scanned digital copy included as part of your report. Calculations - any calculations used on the original data shown as examples. Citations - list any references used, use standard ASCE format.

ASSESSMENT

The author is waiting for the approval from institutional review board (IRB) as of now and for that reason assessment part is very limited. It is limited to instructor's perspective and experience. Once author gets the approval from IRB, he plans to add more information here and provide more details in this section.

INSTRUCTOR REFLECTION AND CONCLUSIONS

Students like hands-on part of the course better than lecture portion. However, I have seen a notable and clear change in the level of students' involvement even in the class lectures since these changes were implemented. This may be partially due to their active involvement in the course. When I reflect on the experience and the outcome, I conclude that I am heading the right direction. For the future, I plan to make technical report writing part a little less time-consuming, add reflection questions and more thought-provoking activities. I plan to conduct a formal and more in-depth study. I hope to navigate the IRB approval process a little better and ahead of time for me to include more data in my future work.

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