Incorporation of Project-Based Learning in an Environmental Engineering Course at The Ohio State University

Harold W. Walker, Shann Coleman, Megan Gaberell
The Ohio State University

Abstract

This paper describes the development of "real-life" projects for the course CE610 Analysis of Natural and Polluted Water at The Ohio State University. The overall aim of the projects was to have students work in conjunction with local government and community groups on water quality problems affecting central Ohio. During Autumn Quarter 98 students worked on two independent projects: (1) An assessment of water quality in recreational ponds operated by the City of Columbus, and (2) a survey of the water quality in the Olentangy River for a community group called Friends of the Lower Olentangy Watershed (FLOW). To carry out the projects, different teams of three students each were assigned to the following tasks: water sampling, sample analysis, synthesis and report writing, and preparing a final presentation. At the end of the quarter, the students submitted formal reports to the City of Columbus and FLOW describing the results of their projects. The students also gave a formal presentation to FLOW at their monthly public meeting. Incorporation of community-based projects into the curriculum improved open-ended problem solving and team work skills of the students, and also enhanced student understanding of societal impacts/contemporary issues. Feedback on the projects from students, the City of Columbus, and FLOW were all very favorable.

1. Introduction

It is recognized that engineering education today must provide both a sound grounding in engineering fundamentals as well as detailed knowledge of the practical aspects of engineering design and implementation [1, 2]. One way to encourage this shift from simple "analysis" to "synthesis" and "evaluation", is to incorporate real-world problems in the curriculum, provide the opportunity for students to work in teams, and nurture students' ability to analyze results and integrate science with practical knowledge.

The learning objectives outlined above are especially important for environmental engineering education. Environmental projects require a multidisciplinary approach and have significant societal implications. To function effectively, an environmental engineer requires both a strong background in state-of-the-art analytical techniques as well as experience using these techniques to evaluate and solve societal problems. One of the most common approaches to accomplishing these educational goals is through the implementation of project-based learning [3, 4].

During Autumn Quarter 98 students at Ohio State University worked on two independent projects in the class CE610 Analysis of Natural and Polluted Water. CE610 is a required, senior-level course in the environmental engineering curriculum and is taught every Autumn Quarter. Topics covered include basic water quality analysis techniques, equilibrium chemistry of natural waters, and chemical concepts of select water treatment processes. The course typically has an enrollment of 40-60 students, primarily senior undergraduates. About half of the students in the course are civil engineers and the remaining students come from Chemical Engineering, Nuclear Engineering, Geology, Environmental Science, and Agricultural Engineering.

The two projects developed for CE610 this past year included: (1) An assessment of water quality in recreational ponds operated by the City of Columbus, and (2) a survey of the water quality in the Olentangy River for a community group called Friends of the Lower Olentangy Watershed (FLOW). A major component of these projects was the participation of both the City of Columbus and FLOW during all stages of the project.

At the beginning of the Autumn Quarter, the students were introduced to the two projects. Different teams of 3 students each were assigned to each of the following tasks: water sampling, sample analysis, synthesis and report writing, and preparing a final presentation. To guide student's efforts, each team was given a detailed outline of the tasks to complete. Handout materials were also given, including a sampling procedures manual, laboratory analysis manual, sampling site reconnaissance worksheets, laboratory analysis bench sheets, and an outline of the final report.

2. Water Quality Projects

Project #1. Water Quality of Whetstone Park, City of Columbus

The water quality of ponds, lakes, and streams in city parks is an important issue facing many park managers because of the aesthetic and recreational purposes these water bodies serve. In CE610, a water quality study was performed on a pond located within the borders of Whetstone Park, a popular recreational park in north Columbus. This particular pond was chosen by the City of Columbus Division of Recreation and Parks in order to determine the effects of switching the pond's source water from city-supplied water to groundwater pumped directly from a well at the site. In conjunction with the Parks Division, students at Ohio State University assessed the water quality of the pond in Whetstone Park.

The sampling team performed an initial reconnaissance of the area to develop a sampling plan for the pond early in the semester. A survey of the pond and the surrounding area was completed, and the condition of the pond and potential sampling points were also noted. The sampling team then carefully chose the sampling points to represent the water quality of the entire pond. Next, equipment and transportation needs were determined for collecting grab samples and returning them to the university for analysis. Finally, the sampling team prepared a plan detailing the exact location of each sampling point, the

type of analysis to be performed, and the types of sampling containers and storage requirements necessary for each type of analysis.

The pond in Whetstone Park consists of an engineered structure, with concrete walls and sidewalks surrounding the pond. The pond itself is "J" shaped, with the inlet located at the top of the "J" and the outlet located at the bottom of the curve. To prevent surface water drainage into the pond, the sidewalks sloped back away from the pond. Two bridges span the pond, making a boat unnecessary for sample collection. Water pumped from a nearby groundwater well keeps the pond at a constant depth of approximately 2.8 feet. The sampling team also noted the presence of algae in the pond, and also fecal matter from the ducks and geese in the pond.

On November 5th the sampling team collected samples from the inlet, outlet, and stagnant portions of the pond. Samples were also taken from the middle of the pond and close to the walls of the pond, for a total of eight samples. After the sampling team collected the grab samples and returned them to the university, the analysis team conducted tests to determine the following water quality parameters: pH, alkalinity, hardness, turbidity, total organic carbon, dissolved oxygen, total orthophosphates, and temperature by standard procedures [5].

The results of the analysis on the samples show that the water in the Whetstone Park pond compares favorably with typical surface water and groundwater in the area. The inlet water from the new well, however, had an anomalous dissolved oxygen value of 1.8 mg/L, while the rest of the pond had DO values ranging from 9.1 to 11.2 mg/L. In addition, there was a strong sulfur odor originating from the inlet well water during the time samples were taken. Based on these data, the students determined that the shallow depth of the pond allows for sufficient oxygen dissolution to aerate the poor quality source water and support normal pond operation. The project team determined that future water quality sampling should focus on examining the sulfur speciation and distribution in the pond and potential impacts of sulfur on the resident biota.

The details of the water quality study, including the sampling plan, raw data, discussion of the results of the analysis, and suggestions for future studies at the pond were compiled into a final report. This report was submitted to the City of Columbus Division of Recreation and Parks. Mr. Robert Ames, Assistant Director-Parks, was very pleased with the results of the study. He commented, "I welcome future ventures that will be meaningful to your students and beneficial to the Columbus Recreation and Parks Department…Columbus is better because of your efforts." [6]. In conclusion, the instructional exercise completed as part of the civil engineering curriculum was productive for the students and beneficial to the community of Columbus.

Project #2. Olentangy River Water Quality Survey

During Autumn Quarter 98 students in CE610 also conducted a water quality survey of the Olentangy River. This river is enjoyed by many as a source of recreation in the Columbus area and is used as a source of drinking water. The survey was completed to

assist the Friends of the Lower Olentangy Watershed (FLOW), a local non-profit organization, assess the water quality of the river and compile a watershed action plan. The mission of FLOW is to increase public awareness of the extensive recreational, cultural, historic, and environmental resources of the Lower Olentangy Watershed, and to promote responsible policies and uses of the river. The student project assisted FLOW in developing a sampling program and collecting preliminary water quality data.

Similar to the work carried out at Whetstone Park, the sampling team initially performed an initial reconnaissance of the Olentangy River to develop a sampling plan. This was an important component of the project because it provided a step-by-step guideline for future monitoring programs and site investigations that FLOW could use in latter studies. In the end, approximately 16 sites were chosen for sampling along the Olentangy River and its tributaries. Sites were chosen to examine the influence of treated wastewater, combined sewer overflows, green spaces, and urban tributaries on the water quality of the Olentangy.

On November 6th and 8th, the sampling team collected samples from the Olentangy River and its tributaries. The sampling was carried out on a clear day after an unusually dry fall. After the sampling team collected the grab samples and returned them to the university, the analysis team examined the pH, alkalinity, hardness, turbidity, total organic carbon, dissolved oxygen, total orthophosphates, and temperature of the samples. The analysis of the samples showed the water to be of fair to good quality at the time of sampling, with moderate dissolved oxygen concentrations, low turbidity, and low levels of phosphates. The project team determined that future water quality sampling should focus on examining the effect of wet weather conditions on the water quality of the river. In addition, the students recommended that future surveys also include hazardous organic compounds and heavy metals analysis, two potential contaminants in the urban region of the Olentangy.

At the end of the quarter, the students submitted a final report to FLOW describing the results of the survey. The students also gave a formal presentation to FLOW at their monthly public meeting. In the end, feedback about the projects from the students and FLOW were all very favorable.

3. Conclusions

In this project, students conducted water quality surveys, in conjunction with local government agencies and community groups. The incorporation of these projects into the curriculum improved open-ended problem solving and aided the development of student teamwork skills. Working with agencies outside of the university greatly increased the significance of the projects, and subsequently increased student interest. The submission of formal reports to outside agencies and presentations at public meetings improved the communication skills of the students, and provided motivation for carrying out the project. In future years, students taking CE610 will build on the water quality surveys conducted this past Autumn Quarter.

4. Acknowledgment

The authors would like to thank all the students in CE610 for carrying out the bulk of the work described in this report. In addition, assistance from the City of Columbus Division of Recreation and Parks and the Friends of the Lower Olentangy Watershed is also gratefully acknowledged. This project was funded as a subproject by the Gateway Engineering Education Coalition – Phase II, NSF award number EEC-9727413.

Bibliography

[1] Pauschke, J. M., Ingraffea, A. R., J. *Prof. Issues Eng. Ed. Practice*, 122, 123-133, 1996.
[2] Accreditation Board for Engineering and Technology, Engineering Criteria 2000, Second Edition, Baltimore, MD, 1997, 6pp.
[3] Juhl, L., Yearsley, K., and Silva, A. J., *J. Chem. Ed*., 74, 1431-1433, 1997.
[4] Ford, D. L., et al., "Role of Design and Operation in Environmental Engineering Education", in Baillod, C. Robert (Ed.), Proceedings, Fifth Conference on Environmental Engineering Education: Integrated Approaches, Computers, Design and Operation (Michigan Technological University, Houghton, Michigan, July 21-23, 1986, 128 pp.
[5] Standard Methods for the Examination of Water and Wastewater, 18th Ed., APHA-AWWA-WPCF, 1998.
[6] Personal Communication, Mr. Robert Ames, Assistant Director Department of Recreation and Parks, City of Columbus, January 4, 1999.

HAROLD WALKER
Harold W. Walker is an assistant professor in the Department of Civil and Environmental Engineering and Geodetic Science at The Ohio State University. He received a B.S. in Environmental Engineering from California Polytechnic State University in San Luis Obispo. He earned an M.S. and Ph.D. in Environmental Engineering from the University of California, Irvine. He teaches courses in water chemistry and water treatment technology and conducts research in the general area of physical/chemical processes.

SHANN COLEMAN
Shann Coleman is a Masters Candidate in the Department of Civil and Environmental Engineering and Geodetic Science and in the Nuclear Engineering Program at The Ohio State University. He received his B.S. in Nuclear Engineering at the University of Tennessee, Knoxville. His current research topic is an environmental risk assessment in transporting spent nuclear fuel across Ohio's highways.

MEGAN GABERELL
Megan Gaberell is working towards a Masters degree in the Geological Sciences department at Ohio State University. She received a B.S. in Geological Engineering from the University of Wisconsin-Madison. As a graduate research assistant, her research focuses on natural organic matter from a stream located in Lebanon State Forest, New Jersey.