GO WITH THE FLOW: A DESIGN PROJECT TO BUILD COMMUNITY

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Abstract *— This paper will describe the implementation of a hydraulic flume project that integrates an academic club project with a senior engineering design course and an introductory level engineering design course. This flume project incorporates multiple educational objectives including the demonstration of engineering design principles, community education outreach, service learning and peer mentoring.*

Index Terms — Engineering Design, service learning, peer mentoring, HSU Society of Women Engineers.

INTRODUCTION

Many engineering educators appreciate the value of experiential education. There is substantial literature supporting the notion that student learning is enhanced and student interest is stimulated when academic activities are interactive, collaborative and hands-on [1]-[5]. One of the more challenging learning objectives identified by our engineering faculty is that graduates will be able to effectively and professionally communicate ideas and technical information to the public and to fellow and other professionals. This paper describes a project implemented at Humboldt State University where we focus on the learning objectives of writing, speaking and collaborative group activities to communicate the engineering principles. This is demonstrated in the design and presentation of a hydraulic flume.

This paper will describe: (1) the physical attributes of flume, (2) how the flume project was incorporated into the ERE curriculum, (3) the educational outreach component of the project, (4) a summary of the benefits of the project and (5) reflection on implementation improvements for Fall 2001 courses.

PROJECT OVERVIEW

In the fall of 1998, the Humboldt State University student section of the Society of Women Engineers requested the fluid mechanics class (ENGR 333) design a flume for children to be used in the Redwood Discovery Museum. The 40 students worked in teams and submitted 10 designs. After 2 years of fund raising was completed, the best 3 designs were combined and Cliff Sorensen, the technician for the HSU Environmental Resources Engineering department, built the flume in the fall of 2000. In the 2000 - 2001 academic year senior level river hydraulics students (ENGR 448) and first year introduction to design students (ENGR111) completed inserts, web pages and display boards to accompany the flume.

THE FLUME

The Humboldt State University Society of Women Engineers flume is an interactive water physics display that has been donated to the Redwood Discovery Museum, a local children's science museum. The purpose of the flume is to engage children so they can learn more about what engineers do. The view of the flume shown in Figure 1 is from the tailgate looking up towards the headworks.

FIGURE. 1
THE HUMBOLDT STATE UNIVERSITY SOCIETY OF WOMEN ENGINEERS FLUME

The flume is approximately 8 feet long, 3 feet wide and consists of a Plexiglas tank, aluminum siding, and a steel base that serves as the reservoir. It holds 100 gallons and circulates water with a 1.0 HP pump. A single sheet of

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Plexiglas is used to separate two six-inch wide channels. The channel slope is adjustable using an air jack. Opening or closing the sluice gates at the entrance controls the flow rate of each channel. The outflow is made adjustable using hinged doors that may be lifted or lowered.

INCORPORATION INTO THE CURRICULUM

The flume project incorporates multiple educational objectives including the principles of engineering design, community educational outreach, service learning and peer mentoring. The manner in which it was integrated into the Environmental Resources Engineering curriculum at HSU is outlined in this section. The flume project has been or will be incorporated into four different engineering courses ranging from introductory to senior level design courses. These courses include:

- Engineering 111: Introduction to Design
- Engineering 333: Fluid Mechanics
- Engineering 418: Applied Hydraulics
- Engineering 448: River Hydraulics

ENGR 333: Introduction to Design

In the Fall of 1998, a junior level fluid mechanics class took on the design of the flume as a class design project. The students worked in teams of 4, interviewed the director of the Redwood Discovery Museum and developed designs of both the flume and flume experiments that could be completed by 5-10 year old children. The best 3 designs of the 10 reports were selected by a panel of judges that included the fluid mechanics instructor, the Redwood Discovery Museum Director and the SWE officers. Students turned in final design reports for academic credit. These design reports were kept on file for future students to review.

ENGR 418/448 : Senior Level Hydraulics

In the Fall of 2000, a senior level hydraulics class designed and built inserts for the flume. Each of the 20 students enrolled in the class was required to submit a preliminary design report. This report included the following components:

- Problem definition and objective statement
- Literature Review and Theory
- Description of Flume insert
- Autocad drawing with appropriate dimensions
- Application - Experimental Results
- References

After the preliminary reports were submitted, the students presented their designs orally to the class. Out of the 20 preliminary designs, the students voted on 7 to implement. In some cases several similar designs were combined. The class chose designs that were most likely to successfully demonstrate the desired hydraulic engineering principle, most likely to be successfully built, and most interesting to the students.

Students then worked in groups of 3-4 to build and test their insert designs. Funding was provided by SWE for the insert materials and technical assistance in building was provided by Cliff Sorenson. One of the inserts designed and built by a senior engineering student is shown in Figure 2 below. This particular insert is a bridge with removeable columns so that students can observed the effects of more or less piers supporting the bridge. Some of the inserts that have been completed include:

- Spring-loaded gate
- Bridges with different Pier Designs
- Velocity Meters
- Broad-Crested Weir
- Two roughness mats

The total project was 15% of the course grade. The senior engineering students were required to submit their work electornically to SWE. The electronic reports have been made available for Engineering 111 students who are working on information web pages and display boards. These materials were used by students in Natural Resources and Interpretation to develop interpretive signs for the Redwood Discovery Museum.

FIGURE. 2
A BRIDGE PIER INSERT WITH REMOVABLE PIERS

ENGR 111: Introduction to Design

The ENGR 111 students have been involved for the past two semesters developing web pages describing the flume and its inserts as well as display boards to accompany the flume on outreach visits. In the fall 2000, 13 ENGR 111 students choose to develop display boards for the inserts that were designed and built the ENGR 448 students. The first year students were assigned to work with particular ENGR 448 students to learn more about the flume and the particular

insert. The ENGR 111 students reviewed the seniors' design documents and communicated with the seniors until they understood the concepts well enough to describe it on a display board.

In the spring of 2001, about 25 ENGR 111 students designed web pages or display boards for the flume. The web pages and boards will be used to explain fluid mechanics topics to students and teachers that are interested in the flume. The web and display information on the inserts describes what the insert is and provides direction on how students or teachers can conduct inquire based experiments wih the flume. Some of the topics include:

- What is a flume?
- Why do engineers study flumes?
- What is a hydraulic jump?
- How to measure the volumetric flow rate
- How to move and store the flume
- Spring-loaded gate
- Bridges with different Pier Designs
- Velocity Meters
- Broad-Crested Weir
- Roughness mats

The SWE officers review the work of the ENGR 111 students. Those web pages that are chosen will be housed on the Society of Women Engineers' web site. The boards that are chosen are developed into display boards using funds raised by the SWE club.

EDUCATIONAL OUTREACH

The flume has been in use since November of 2000. It was debuted on a Saturday at the Bayshore Mall in Eureka California during "Building Big-A-Thon" sponsored by the local chapter of the American Society for Civil Engineers. Figure 2 is a photograph showing children playing with the flume at the mall. The flume has also been taken to a local high school where math students completed flow calculations. It has been taken by SWE members to local middle schools to encourage girls to participate in the Expanding Your Horizons conference for 6th, 7th and 8th grade girls. It has also been used by the Environmental Resources Engineering Student Association and the society of Women Engineers at the career fair held at Humboldt State Univeristy. Over 1000 9th -12th grade students attended the fair.

FIGURE. 3
CHILDREN PLAYING WITH THE FLUME AT THE BAYSHORE MALL

The Redwood Discovery Museum held it's grand openng on March 3, 2001 and the flume is in place as an exhibit. The flume will be a permanent learning tool for children of all ages in the Redwood Discovery Museum. SWE has an agreement with the Redwood Discovery Museum that the flume will be made available for educational outreach conducted by the SWE students. The permanent exhibit at the museum is shown in Figure 3.

FIGURE. 4
THE FABULOUS FLOWING FLUME EXHIBIT AT THE REDWOOD DISCOVERY MUSEUM IN OLD TOWN, EUREKA, CALIFORNIA

PROJECT BENEFITS

We are realizing multiple benefits through this project. As a program we would like our students to learn problem-solving and lifelong learning skills and the ability to

communicate effectively and work as part of a team. This project provides access to these goals to *all* students. Engineering students from all levels have been involved in the design, construction and educational outreach aspect of this project. The students are provided a chance to talk about and demonstrate principles of fluid flow and they are enjoying their education by teaching others how to learn from the flume.

Introductory Student Benefits

Freshman or introductory level students need to talk to senior level students in order to design their information boards and web pages. This requires that they meet and work with senior level students. Introductory students are provided an early opportunity to join the student community within the engineering department and they are given access to an opportunity for informal peer mentoring. Introductory level students also are given a sneak preview to more advanced engineering design topics and see a hands-on application for the concepts they are or will very soon be presented.

The introduction to design students are also given the opportunity for experiential learning in what has traditionally been a large class at Humboldt State University. The total enrollment over the past three years has been in excess of 50 students. In the Fall of 2000, when this project was first implemented, there were 75 students in the introductory course. Students were given the option of choosing this project or another project that has been presented in this course before. We believe that the majority of the students chose the other project because the flume project was veiwed as new and a bit risky. Feedback from a student who chose to design a display board for the flume is presented below.

> *This process allowed me to further my problem solving skills while, at the same time, enhancing my ability to present information, attract an audience to the information, and maintain a consistent level of interest in the information presented.*
>
> *I found that this project gave me the true understanding of what designing for a client really means. (Engineering 111 Student, Fall 2000).*

Senior Level Student Benefits

The senior level engineering students are required to explain and present their flume insert designs to students with very little background in fluid mechanics. This provides them an opportunity to develop their understanding of the concepts they are using in their design process in an informal and friendly atmosphere. The senior designers are seen as the experts in the engineering student community and they developed greater confidence in their technical knowledge and their ability to communicate that information.

From a design perspective, the seniors follow through a design project from concept to implementation and are also given the opportunity to reflect on the effectiveness of their design. We provide a high quality educational experience because the flume has high visibility within the department and in the community. Students want their inserts and displays to be of high quality and educational and they see how the community reacts to their efforts. By becoming involved in the implementation of their design students are allowed to reflect on and assess the value of their applied academic experience.

By chance, many of the students who were in the fluid mechanics class that provided the initial designs for the flume were in the river hydraulics class two years later.

> *I particulary enjoyed this project because in Engineering 333 I was involved in the original design of the flume. ... builidng the insert also helped me realize (again) how a design changes before it reaches final form. Seeing the flume project progress from an idea, to design reports, to a physical flume has been slow, but exciting, and I'm glad to have been provided the opportunity to continue my participation. (Engineering 448 student)*
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> *The project was definitely a learning experience. I think it made most students realize that a design that seems fairly simple on paper can be quite a challenge to create in real life. (Engineering 448 student)*

Benefits to Non-Traditional Engineering Students

The fact that the project is initiated and run by the students in the Society of Women Engineers means that the women in the department are seen as the experts on this equipment and it provides a supportive environment for other women within the department. In class sessions where we have presented the flume to a group of students, the women in the class do not hesitate to step up and experiment with the flume. In previous literture, it has been observed that women are often more hesitant to take initiative in a more traditional laboratory with technical equipment. Additionally, through the educational outreach, local children will be introduced to possible engineering careers and science and are exposed to female engineering role models.

FIGURE. 5
SWE STUDENTS CONDUCTING OUTREACH ACTIVITIES WITH THE FLUME.

The environment created by this project is supportive. Fluid mechanics is a traditionally difficult subject and may be viewed as the proper domain of only a few. The flume project is made accessible to all levels, children through senior level undergraduates in engineering. Every student who interacts with the flume is presented the opportunity to understand what engineering is. The displays and web page information stresses an inquiry based approach to the flume, so that questons are posed, suggestions are made and students learn about hydraulics and laboratory scale models. It is not a hands-on experience where you simply get wet.

IMPROVEMENTS FOR FALL 2001

We intend to keep the flume project in the engineering curriculum for the Fall of 2001. Engineering 111 introduction to design students will continued to be involved in designing informational display boards and web pages and developing curricular material for local area teachers.

The senior level applied hydraulics class (Engineering 418) will design and build new inserts for the flume. Students will be given two choices in insert designs: (1) choose an entirely new insert to demonstrate a fluid flow principle that is not currently demonstrated, or (2) design a replacement for an existing insert that is either breaking down or not functining properly.

The peer mentoring aspect of the interacton between the Engineering 111 students and the Engineering 418/448 students must be improved to facilitate more positive interaction. It is clear from feedback from last semesters students that we need to provide more structure in the peer mentoring aspect of this project. We need to provide more structure as to when the students should meet and how to evaluate the process within the context of the course. Incorporating those learning objectives into the upper division courses is critical.

The seniors I was supposed to be working with were hard to reach, and supplied very little insight as to their desired goals. (Engineering 111 student)

We didn't have much incentive to work with the 111 students, so the bulk of our communication was through email. I think had that part of the project been a bigger part of the class, then we would have communicated more enthusiastically with the 111 students. (Engineering 448 Student)

Overall, I think this is a very good idea for a project, and a good way to get 111 students in touch with older students. (Engineering 448)

CONCLUSIONS

Overall the implementation of the flume project has been successful in meeting multiple learning objectives. The design and construction of the flume has been used to demonstrate engineering design principles in several engineering courses (Introduction to Design, Fluid Mechanics and River Hydraulics). The demonstrations of the flume have created a community among engineering students involved in the educational outreach and SWE academic club activities. This community of students who have chosen to become more involved in the flume project outside of their coursework has provided for informal peer mentoring opportunties. The more formal peer mentoring aspect between introductory level engineers and senior level engineers has been less succesful in implementation and will be the focus of our improvement for the Fall of 2001.

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