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Project-Based Service Learning for First-Year Engineering Students in Partnership with the Graduate Teaching Fellows

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Abstract **- Service Learning is one of the emerging concepts that are becoming popular in the education of undergraduate students. Considering the empirical approaches, the objective of service learning is to provide an opportunity for students to be more engaged in using their engineering concepts and potential for satisfying individual human, and community needs. Additionally, Project-Based Service Learning (PBSL) has been recognized as an effective active learning tool in engineering education. The College of Engineering at Colorado State University has developed a new program entitled the Graduate Teaching Fellowship for ten graduate students to provide additional assistance in First Year Engineering courses and to do research about retention data of first year students in college of engineering. Considering the result of the study, the principle goal of this program is to increase the retention statistics for engineering students. Each of these fellows has been assigned to one engineering department. Using the help of this graduate fellow in the Civil and Environmental Engineering department, the curriculum of the first-year course entitled "Engineering Graphics and Computing" has been changed through an addition of a design project. This project is based on the Engineering without Borders (EWB) Challenge (www.ewbchallenge.org) which lets the first-year engineering students work on an international project, which tries to develop the quality of life in locations where people live in poverty such as the Mayukwayukwa refugee settlement in Zambia. This paper discusses the organization of integrating the project into the course, difficulties that have arisen, and benefits of having this project in the first-year engineering course. Design details of the Graduate Teaching Fellow position and its incorporation into the course organization is also described. As an experimental program designed to enhance the first year experiences, valuable lessons have been gained.**

Index Terms – Project-Based service learning, EWB Challenge, Graduate Teaching Fellows, and First-Year Teaching Experience.

INTRODUCTION

Learning quality has been one of the crucial aspects that play a major role in students' future and keeps them interested in their education and professional life. Consequently, a different methodology has been introduced to assist students staying passionate about their studies. Service learning is one of them. Service Learning (SL) is defined as: "course-based, credit-bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader application of the discipline and an enhanced sense of civic responsibility" [1]. Considering society's needs, students are led in solving real-world engineering problems using the concepts of their engineering studies. Consequently, students feel more engaged in their education and this open the door to be more passionate about their learning in universities [2].

Project-Based Service Learning (PBSL) is one of the methodologies that have been used to apply the concept of service learning in which the students are assigned to work on a real engineering project in their learning process instead of having an assumed project assigned by instructors [3]. This methodology has been applied in many cases and the results illustrate that PBSL is a powerful active learning tool that can be very helpful for both students and society [4].

The college of Engineering at Colorado State University has introduced a new program entitled "Graduate Teaching Fellowship" for ten graduate students to work on the retention of first-year engineering students. Also, they should do research about the reasons behind why students have left engineering, collaborate with the instructors to provide additional assistance for students and help students to remain in engineering to their second year [5], [6].

In this program, two students were assigned to each department, including, Biomedical Engineering, Chemical and Biomedical Engineering, Civil and Environmental Engineering, Electrical and Computer Engineering, and Mechanical Engineering. For Civil and Environmental engineering, using the assistance of one of these fellows, the curriculum of the course entitled "Engineering Graphics and Computing" has changed. This class includes 186 students, 3 teachers, 5 teacher assistances, and 1 Graduate Teaching Fellow (GTF). The class is held in two sessions per week. Also, required to register for one of six available laboratory sections. The course characteristics are as bellow:

- This is the second course in the first year sequence (CIVE 102-103) designed to give students an introduction to Civil and Environmental Engineering.
- This course has the following objectives:

    1. To develop an understanding and/or proficiency with topics and tools commonly used by Civil and Environmental engineers in daily problem solving endeavors including Excel, Data Analysis, and AutoCAD.
    2. To develop an appreciation of professional topics, including, Structural, Geotechnical, and Sustainable Engineering.
    3. To complete a project involving the design, construction, and testing of a model building frame under earthquake type loadings.
    4. To develop an understanding of design activities through a group project on an international design project.

To satisfy the fourth objective, using the concept of PBSL, a semester-long project was assigned to the students. This project is based on the Engineering Without Borders (EWB) Challenge. The project is designed for first year engineering students to work on a project with an objective of empowering communities and poor countries by addressing a set of engineering-related needs. To accomplish this goal, students propose their ideas addressing the real world problems which give them a sense of purpose. The location of this year's project is a refugee settlement in Mayukwayukwa, Zambia.

This Paper analyzes the procedure that has been implemented for this course. Also, feedback from the GTF, instructors, and students illustrate the effectiveness of this methodology.

EWB CHALLENGE

The Engineering Without Borders Challenge (EWB) is a design project developed for first year engineering students to provide an opportunity for them to learn about the engineering profession and develop some necessary skills for professional life, such as, communication, responsibility, teamwork, and decision-making [7]. This project is coordinated by the Engineering Without Borders organization in Australia, founded at 2007, and operates in partnership with non-government organizations such as the United Nations High Commissioner for Refugees (Zambia) and Habitat for Humanity (Vietnam).). Other countries such as the United Kingdom, New Zealand, and Ireland are collaborating on this project, as well as universities in Malaysia, and Colorado State University in the United States. Alongside providing experiential education for engineering students in these countries, the primary objective of the project is to provide an engineering support and ideas for communities in developing countries. The EWB Challenge has been recognized in conferences in Europe and Australia in recent years regarding its focus on creating a sustainable design and it has been a subject of a collaborative Australian Government Learning and Teaching Council research project grant [8].

The EWB Challenge is part of the wider EWB goal of a transformed engineering sector so that every engineer has the knowledge, experience, and skills, to contribute towards poverty alleviation and sustainable community development as well as an understanding of the responsibility of engineers as global citizens [9]. Each year, the EWB Challenge design brief is based on a set of sustainable development projects identified by the EWB Challenge Development team, based at EWB-Australia, with a different community-based partner organization [8]. In past years, the EWB Challenge has included developing project ideas to support communities in Cameroon, India, Cambodia, Timor Leste, Nepal, rural Australia and Vietnam.

The EWB Challenge has been applied in first year engineering courses and can be adapted to earn credit for the class as well as creating a flexible model for students to learn about sustainable design [10].

One of the current EWB challenges is to build a refugee settlement in Mayukwayukwa, Zambia. This project has nine different design areas including:

- Water Supply and Sanitation.
- Health
- Energy
- Waste Management
- Transportation
- Information Communication Technology
- Climate change and agriculture
- Food Processing
- Shelter

IMPLEMENTATION

Using the assistance of the GTF, the following procedure has been done to implement the idea of applying the PBSL in the course:

- First, a lecture has been allocated to help the students become familiar with EWB challenge, the objectives of the project, and overall barriers that people are dealing with in Zambia. Also, they have been guided to use the website (http://www.ewbchallenge.org/unhcr-zambia) and received instructions on how they can access the information on the website and search for more specifications they need for the project.
- Second, the students were assigned to their group based on their professional areas of interest and their interest in particular design areas. Each team consists of 3 to 5 students and they were assigned to identify one person as group communicator for the next steps.
- Third, a second homework was assigned to students. This assignment was a group assignment and each group communicator submitted one report for their group. In this homework two different questions had been targeted:

    1) The group was asked to select their subject among the available design areas and their reasons for this choice. As discussed before, the EWB project in Zambia has nine different design areas with each of them pinpointing to a specific engineering problem. The students selected one of these subcategories as the topic of their project.
    2) To review the design considerations that are addressed in the project description and prioritize them for their effort. This question has been developed to help them think in an orderly manner to find potential solutions for the topic they have selected.

- Fourth, after the second homework, it has been noticed that the groups made a couple of common mistakes:

    1) They did not select a specific subcategory in a design area for their subject. They tended to choose the entire design area as the title of the project. Since each design area has multiple aspect to it would not be possible to cover all of them based on time limitation of the semester-based experience.
    2) Also, they did not understand the concept of the design considerations or how to prioritize them.

  Consequently, the GTF decided to meet with every group individually and guide them in the right direction. In this meeting, firstly, the mistakes were discussed with the students and they were assigned to identify their topic. Moreover, the design considerations were explained to them. Finally, these meetings were wrapped up with talking about the timeline of the project. They were required to subsequently send the GTF three weekly reports to explain their progress. This allowed the GTF to follow up with them and assist them with their questions and motivate them to do the project consistently.

- For the next step, groups were asked to submit a panel report and finalize their ideas, discuss them in detail, and provide any photo, AutoCAD or Arc GIS map they had developed. Besides, they should check their design with prioritized design considerations to prove that they had worked on these limitations during their design process.
- In the final step, the students were prepared for their final public presentations. The concept behind the presentation is to help students learn to present in public. Also, they shared with the other groups their ideas for the topic and perceive different points of view on an engineering problem. The GTF provided them with a sample PowerPoint presentation which contains the required details for the presentation. The presentations were held for each group during the week before the finals week. Each group had an 11-13 minute time limitation for the presentation and each group member was required to present. In addition, the presentations were graded based on the several factors, including: clarity of presentation, content, team effort, appropriate use of time, design and layout of slides, and creativity. The presentation should include an overview of the EWB project and the selected topic, different solutions that they have worked on and their reasons about selecting the final one, provide their final design in great details (AutoCAD, ArcGIS Maps, and other proofing details of their design), check the solution with design considerations and give feedback about the whole project.
- The entire process has been done in one semester which was Spring semester of 2017. This work has not been submitted on the website, yet.

FEEDBACK FROM STUDENTS

In the last class of the semester and during the group presentations, the instructors, as well as the GTF, tried to collect the students' feedback about the procedures they have followed and compare it with a traditional project (same project assigned to all students in the class) assigned by the instructor in previous semesters:

1) The students were satisfied with their freedom in selecting the topic of their project based on their interest. They mentioned that since civil engineering has different independent branches, they might not be interested in some of them. So, having a choice can motivate them to focus on the area that they would like to choose in their professional life after their graduation. Consequently, they worked on the project consistently and patiently.

2) They liked the homework assignments and the assigned reports because it helped them to develop the project gradually. Also, they mentioned that these assignments were helpful in their preparation for the final presentations.
3) They find the individual meetings with the GTF to be very helpful. This provided an opportunity for them to get to know the GTF better and to contact her during the process. In addition, they have mentioned that this meeting had helped them to continue the project more strictly, because it emphasized they were dealing with an organized project that required strict team supervision.
4) The PowerPoint slide that had been presented in one of the lectures by the GTF was helpful for them to know what they should mention in their presentation.
5) Since the project was an in progress project and the instructors were not sure about the timeline of the project at the beginning of the semester, they expressed their desire for having an exact timeline at the beginning of the semester.
6) They requested greater allocation of sessions of the labs, possibly every three weeks, to work on the project and having instructor and the GTF in these sessions to help them directly in the design process.
7) They mentioned that they would like to have one more session to learn to how they can create better PowerPoint slides.
8) They found the homework questions comprehensive. It would be better to have the assignments with more details.

FEEDBACK FROM INSTRUCTORS AND THE GTF

Since the idea of having an EWB project as the PBSL was implemented the first time in this course, the instructors and the GTF tried to consider different aspects of having this project in the course. This paper has addressed some of these points:

1) It has been noticed that the students are more committed to applying the new policy in comparison to the traditional assigned project- a common design problem for all students. The reason behind that is first, they have selected the project based on their interests. In addition, since they worked on a real engineering project, which related to the community needs, they feel that they are being beneficial to the community. Therefore, this gives them more desire to work on the project.
2) The size of the class is too big. It was hard to have an individual meeting with them. Maybe for next year applying the meeting in one of the labs would be more helpful.
3) They have not been assigned to have ArcGIS maps and their AutoCAD drawings for their project. Many of the groups provided these details, but some of them did not. It will be better to have this aspect as a required part of the project for each group. This will more tightly connect the course objectives related to these engineering tools and the project goals.
4) It is better to allocate time in the labs regularly to check their idea and help them to think creatively.
5) In grading the part, having a group peer assessment could be helpful to encourage the entire group members contribute on the project.
6) They should submit a more organized final report not as a homework but as a part of their final submission.
7) Overall, it is felt that having this kind of project is very helpful for students. Flexibility of selecting topics and working on these subjects gives the students motivation and creates a sense of community in them. Therefore, they would focus well and they feel that they are more engaged with the engineering world.
8) Due to lack of time, it was not possible to have a survey to officially evaluate the results and to record opinions of the students about the effectiveness of this procedure and whether it could be helpful for the retention of the students in their first year of their engineering studies. Although, after orally asking the students for their feedback, it has been perceived that students were satisfied with what they had done and it plays a positive role in keeping them interested in continuing their education in the engineering field. A companion paper in this conference addresses more formal assessment of student growth related to global awareness in the engineering profession.

RECOMMENDATION

Based on what has been discussed in the paper the authors have the following recommendations for the next implementation:

1) Allocating more time for this project in class and consider assigning a greater percentage of a total score for the course to encourage the students to be more active in the project.
2) Assigning exact details that the students should provide in their final presentation at the beginning of the semester so that they know what feature they should work on the project.
3) Designing a survey and distributing it at the end of semester to perceive the effectiveness of the process and how it would be helpful in retention data.
4) Another recommendation that might be useful to implement the PBSL more effectively is the

allocation of the entire course to EWB challenge and change the outline somehow that the useful materials such as AutoCAD and ArcGIS specifically are designed around the project. It means that the projects and assignment of this portion of the class shall be assigned specifically to the challenge. In this way, better support for students can be provided.

5) Develop better collaboration between the GTF and the instructor. As this project introduced both a new design activity to the class at the same time a new organization with a vaguely defined GTF position was introduced, more effort to collaborate on supporting this effort would be beneficial. The GTF was given much freedom in helping the students, but the instructor could have provided more mentoring and support to the GTF.
6) The EWB Challenge includes a submission process to the international organization for a design competition. Due to financial constraints this aspect was not done. In the future, efforts to secure funds for participating in the competition will occur. This may add additional motivation to the students' efforts.
7) Finally, based on the received feedbacks, we recommend applying the same concept in the curriculum of first-year engineering courses.

CONCLUSION

In this paper, the EWB challenge was assigned to the course entitled "Engineering Graphics and Computing" for first-year civil engineering students at Colorado State University. The objective for applying this idea was to provide a design opportunity for students for them to know real-world engineering problems centered on satisfying society necessities. This may motivate them to continue their engineering education and create a sense of purpose. In this process, a Graduate Teaching Fellows (GTF), who was assigned by the Dean of College of Engineering to help with the retention data of first-year students in the Civil and Environmental Engineering department, gained valuable teaching-related experience by directly supervising undergraduate students.

A summary of what was assigned is as following:

- Assigning the project and letting the students choose their topic based on their interest. Also, this was a group project consisting three to five students in each group.
- Requiring two homework assignments and requesting three reports to be reviewed during the process.
- Having final presentations to share their experience with other students and practice speaking in public skill.

In the final week, they were asked to share their feedback with the instructors and the GTF. Students preferred applying this challenge rather than having traditional projects assigned by an instructor. They mentioned that having the freedom to choose a subject would be a better option and work on real case engineering problem could be helpful to get a better sense of engineering. Moreover, they have mentioned that if the timeline of the project were assigned at the beginning of the semester and more specifically talked about what they assigned to present in their reports, it would be better. In addition, it should be mentioned that since we need to track the data trough semesters to get retention data, we do not have access the retention data at the time of writing this paper. We will work on them for the future paper.

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