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A Project-Based Integrated Work/Review Cycle (PBIWR) for Design and Learning of Accelerated Construction Monitoring

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Abstract

To minimize impact due to travel delay, the US Department of Transportation (USDOT) has been pushing for Accelerated Construction (AC) techniques for public transportation construction. In contrast to traditional construction techniques, the AC technology is envisioned by the federal agency to have the potential to generate great savings for the nation by eliminating unnecessary traffic jams due to slow construction processes.

This change in construction philosophy offers a great opportunity to introduce the advanced concept of full monitoring of structural construction/aging processes via embedded sensing technologies. Since this involves both inspection techniques and construction management, this paper suggests an integrated learning approach that can be applied to a design project-oriented course content that is offered in both Civil Engineering Technology (CIET)/Construction Management (CM) and Structural Monitoring (CEE) courses, such that students from both Departments can work separately, but produce one project outcome. Results from a student survey indicated that this study enhanced students' skills of generating creative and realistic solutions for solving open-ended problems, and promoted an active learning environment by diffusing interdisciplinary knowledge and engaging collaborations amongst graduate/undergraduate study groups.

1. Introduction

1.1 The overall purpose of the study

The overall purpose of this study is to develop a new learning method to enhance student learning and to generate synergistic knowledge through integrated project studies on the subject of Smart Monitoring of Accelerated Construction (SMAC) from undergraduate students attending the ETCE4251- Highway Construction Technology course and graduate students in the CEGR 6090 – Nondestructive Testing course. The ultimate intent is to use and share the lessons learned from the proposed project-based teaching approach to improve engineering curricula, to enhance student learning experiences and to produce better engineers for the society.

1.2 The specific objectives of the study

The objectives of this study are to:

- enhance students' skills of generating creative and realistic solutions for solving open-ended problems; and
- promote an active learning environment, by diffusing multidisciplinary knowledge and engaging collaborations amongst graduate/undergraduate study groups.

1.3 The rational for the proposed study

Due to the social-economic impacts in delayed travels, the US Department of Transportation (USDOT) has been pushing for Accelerated Construction (AC) technologies for public transportation facilities that would minimize delay costs[1]. AC technologies may include optimized construction management delivery techniques or modularized constructions where ready-made structural components can be assembled in a very short time. In contrast to traditional construction techniques, the AC technology is envisioned by the federal government to generate great savings for the nation by eliminating unnecessary traffic jams.

This change in construction technique offers a great opportunity to introduce an advanced monitoring concept for structural construction/aging processes via embedded sensing technologies. On-site construction constantly imposes constraints to system-wide monitoring because the requirement of an embedded sensing system on site would mean a slow-down and disruption of the construction process – an unwelcomed demand on the contractors. However, with modularized construction, the embedment of sensing systems can be performed at the manufacturing level without causing time constraints at the construction site. Also, since the sensor systems are embedded in the pristine structure prior to assembly into the full structure, the sensing system can be mobilized to monitor the structure as early as the construction phase.

The Self-Monitoring Accelerated Construction (SMAC) technology conception represents a true smart system, like the human body, that allows the structure to report defects that may be induced either during construction or during its service life. The development of such technology requires integrated knowledge in civil engineering electronic sensory design, as well as the specific accelerated construction involved. This proposal suggests a joint investigation effort among students between two different disciplines and supervised by faculty specialized in Civil Construction Technologies (Dr. Don Chen – Department of Civil Engineering Technology and Construction Management) and Structural Health Monitoring (Dr. Shen-En Chen – Department of Civil and Environmental Engineering). The conception will be used as the subject matter for a specific class project that will be offered in ETCE 4251- Highway Design and Construction and CEGR 6090 – Nondestructive Testing courses.

The rationale for the multi-disciplinary, project-based course is to optimize the learning experience with supervisor evaluation and to stimulate student creativity. The key pedagogical objective in this study is to establish a potentially creative and synergistic environment for student learning through interactions between multi-discipline teams: Civil Engineering Technology/Construction Management and Structural Monitoring students. The goal is for students to meet the CIET/CM and CEE program outcomes as well as criteria defined in the University strategic planning for student achievements.

However, since the two student levels are distinct, hence, to ensure we understand how each group learn and contribute to the general idea, we intentionally avoid direct interaction between the two groups. This will guarantee that proper observations about the student learning experiences can be attributed to the right process for future improvements on the course content.

1.4 The benefits to student learning and success

This project will generate better-prepared graduates in the subjects of science, mathematics and engineering designs. The CEE program will graduate engineers who are responsible for designing industrial projects; graduates from the CIET/CM program will become construction managers. An engineer who understands how the projects are constructed can generate optimized designs that are easy to be implemented on the job sites; and a constructor who has been exposed to design philosophy is able to appreciate design details, propose feasible value engineering strategies, and fully collaborate with designers. By introducing construction management knowledge to CEE students, and advanced monitoring to CIET/CM students, the researchers expect that a comprehensive grasp of construction and monitoring can be achieved in both groups.

This project will enhance both undergraduate and graduate educations: most of the CIET/CM students involved in this project are seniors, and all the CEE students are graduate students. The breadth and sophistication of knowledge and the level of maturity are different in these two groups. Group reports from one level will be critiqued by students at a different level. i.e., the graduate students will grade group reports developed by the undergraduate students, and vice versa. This is beneficial to student learning because both groups of students can learn how others solve problems from different perspectives.

1.5 Literature Review

An extensive literature review has been conducted to synthesize past and ongoing research related to this study. Interdisciplinary integration in engineering education has been widely adopted by faculty because of improved "awareness of [their] collaborators' perspectives, …, and noted increased satisfaction and quality of work"[2]. This way of teaching creates diversity among engineering students. "..., without diversity, engineering cannot take advantage of life experiences that bear directly on good engineering design" [3]. Optimized designs can be achieved through several inductive teaching and learning methods. Project-based learning (PBL) has proven to be one of the most effective inductive methods [4]. Other promising inductive methods include problem-based learning, case-based learning, discovery learning, and just-in-time teaching. Prince and Felder [5] indicated that these inductive methods "promote students' adoption of a deep (meaning-oriented) approach to learning, as opposed to a surface (memorization-intensive) approach." Whether or not faculty research supports engineering education remains a debate at academic institutions. Waston [6] suggested that the integration of research and engineering education will take place only if research is "translated into changes into faculty, courses, and curriculum."

2. Methodology

This study included the following steps:

1. Developed relevant new course materials, the project description, and the grading rubric;
2. Dr. Shen-En Chen gave a lecture on non-destructive testing and monitoring of bridges in Dr. Don Chen's undergraduate level course ETCE 4251 Highway Design and Construction section 001 (45 students). This lecture was videotaped using Panopto and then played to ETCE 4251 section 090 (32 students).
3. Dr. Don Chen lectured on a similar topic but with an emphasis on accelerated bridge construction to Dr. Shen-En Chen's graduate level course CEGR 6090 Nondestructive Testing (9 students).
4. A group project (Appendix A) was assigned to ETCE 4251 and CEGR 6090 students.
5. Students were asked to grade project reports and redesign the project based on feedback obtained.
6. Faculty compiled and synthesized all assessment outcomes to determine the success level of the project.

3. Materials and Procedure

The effectiveness of this project was evaluated through the following measurements:

- Group project scores from the instructors;
- Peer review scores; and
- Results from the learning experience survey.

4. Results of the Learning Experience Survey

In this study, out of 63 undergraduate students, one was a freshman, one was a junior, and the rest 61 were seniors; 33 majored in Civil Engineering Technology (CIET), 25 were Construction Management (CM) students, and 5 were CIET/CM dual majors. Out of 9 graduate students, one was a senior, four were first year's MS students, and four were second year's MS students; they were all Civil Engineering (CE) students.

Group project scores and peer review scores from the other group are shown in Tables 1 and 2 below.

Table 1. ETCE 4251 scores

	Instructor's Grade	Peers' Grade
CMET 4251 Group 1	65	80
CMET 4251 Group 2	75	82
CMET 4251 Group 3	77	83
CMET 4251 Group 4	60	79
CMET 4251 Group 5	60	68
CMET 4251 Group 6	86	92
CMET 4251 Group 7	86	91
CMET 4251 Group 8	63	72
CMET 4251 Group 9	61	79
CMET 4251 Group 10	70	82
CMET 4251 Group 11	72	89
CMET 4251 Group 12	73	90
CMET 4251 Group 13	80	81
CMET 4251 Group 14	78	82
CMET 4251 Group 15	76	84
Average	**72.1**	**82.3**

Table 2. CEGR 6090 scores

	Instructor's Grade	Peers' Grade
CEGR 6090 Group 1	85	70
CEGR 6090 Group 2	82	64
CEGR 6090 Group 3	92	77
CEGR 6090 Group 4	90	74
CEGR 6090 Group 5	90	86
CEGR 6090 Group 6	95	90
CEGR 6090 Group 7	91	72
Average	**89.3**	**76.1**

Overall, based on the instructors' evaluations and as expected, the quality of group projects completed by the graduate students in CEGR 6090 is better than the ones completed by the undergraduate students in ETCE 4251. The main reason was that this project was essentially a research project. Students needed to conduct a literature review, and then develop their designs. Most of the undergraduate students had no such experiences. This was also the reason that the undergraduate students rated their peer graduate students' projects lower – this project is different from other term projects that these undergraduate students had undertaken.

A learning experience survey was conducted after the group projects were completed. The survey includes 7 questions. The answers are analyzed in detail below.

Question #1: "How many times have you been involved in an interdisciplinary learning experience required for a course?"

Around 76% undergraduate and 44% graduate students had participated in more than two interdisciplinary learning projects.

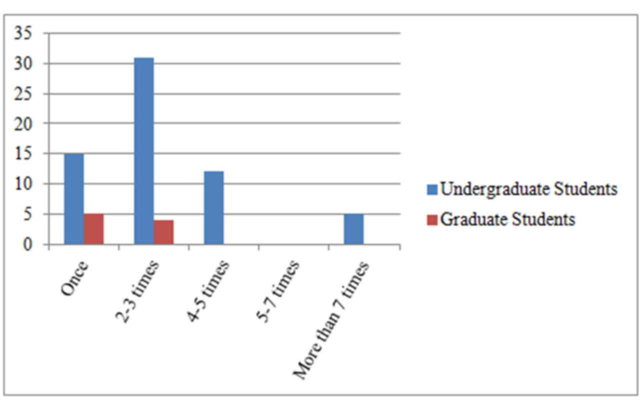

Figure 1. Question #1 Results

Question #2: "Overall, how positive were your interdisciplinary learning experiences?"

The majority of students (71% undergraduate and 89% graduate students) had reported positive interdisciplinary learning experiences from working on this group project.

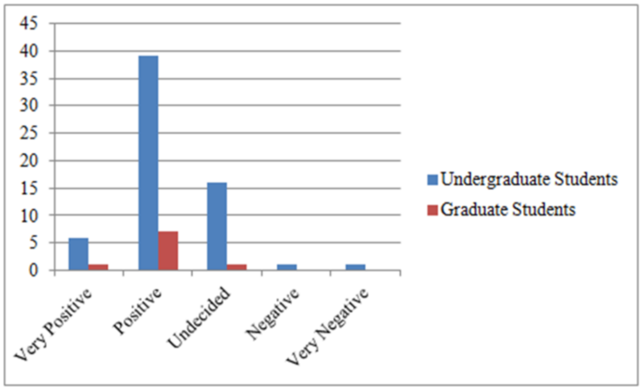

Figure 2. Question #2 Results

Question #3: "In general, to what extent have your interdisciplinary learning experiences emphasized applying course concepts to problems or situations?"

About 50% undergraduate and 70% graduate students considered that the group project was relevant to real-world problems or situations.

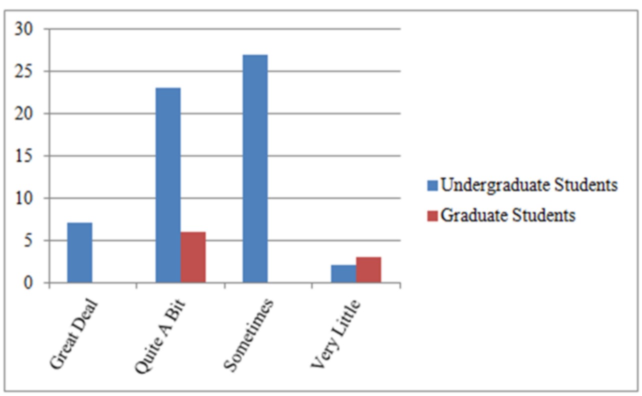

Figure 3. Question #3 Results

Question #4: "To what extent have your interdisciplinary learning experiences emphasized critical analysis of ideas, methods, or theories presented in class?"

About 48% undergraduate and 78% graduate students believed that the group project helped them better understand knowledge taught in class.

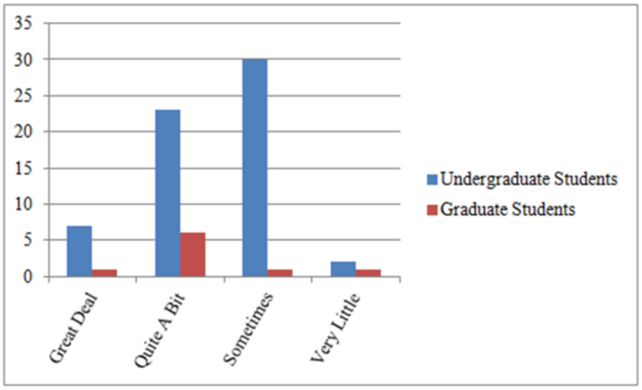

Figure 4. Question #4 Results

Question #5: "Interdisciplinary learning has made me decide to participate in graduate or undergraduate research projects."

About 16% undergraduate and 33% graduate students become interested in participating in research projects.

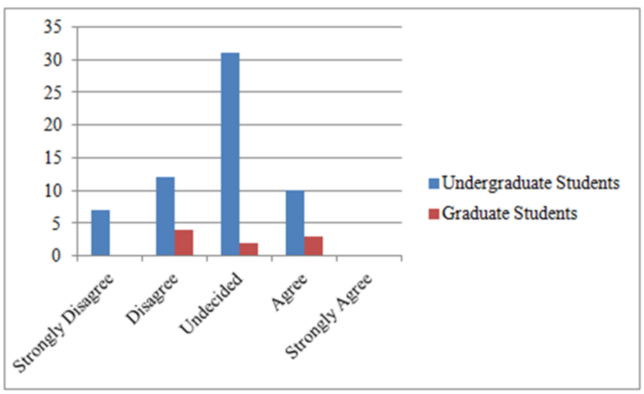

Figure 5. Question #5 Results

Question #6: "Do you feel the opportunity to share a class lecture with a different Department has helped me to recognize the multi-disciplinary nature of my future profession?"

Approximately 62% undergraduate and 56% graduate students recognized that their future profession will be multi-disciplinary in nature.

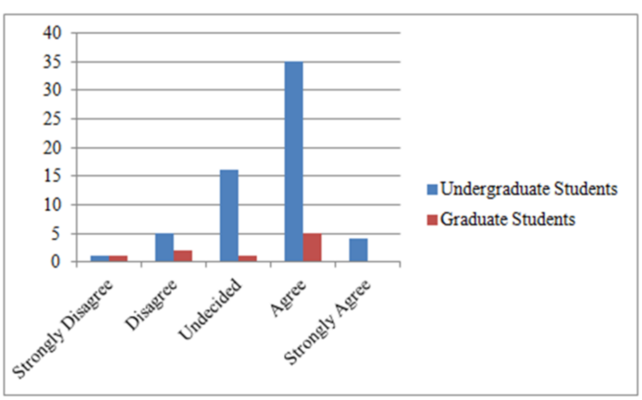

Figure 6. Question #6 Results

Question #7: "The lecture and exercise on Accelerated Construction and Monitoring Methods have helped me recognize the future demand of my profession and have potential impact on my study focuses."

Around 60% undergraduate and 56% graduate students had a clearer understanding of their future profession and study focuses.

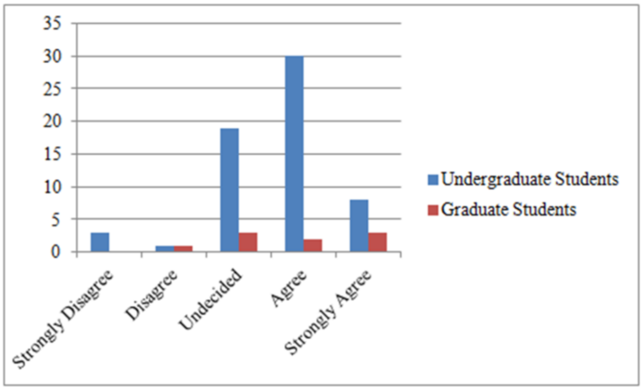

Figure 7. Question #7 Results

5. Discussions and Conclusions

To assess the effectiveness of PBIWR, a learning experience survey was conducted after the cycle was completed. Survey results indicated that through PBIWR, the majority of students (both undergraduate and graduate) reported that:

- they had positive interdisciplinary learning experiences;
- their problem-solving and critical thinking skills were improved;
- some of them became interested in participating future research projects; and
- interdisciplinary learning experiences they gained helped better shape their future profession.

The ultimate goal of this study is to use and share the lessons learned from the proposed project-based teaching approach to improve engineering curricula, to enhance student learning experiences and to produce better engineers for the society. To this end, a project-based integrated work/review cycle (PBIWR) for design and learning of accelerated construction monitoring was develop for undergraduate students attending the ETCE 4251- Highway Design and Construction course and graduate students in the CEGR 6090 – Nondestructive Testing course.

Therefore, it can be concluded that this study was able to enhance students' skills of generating creative and realistic solutions for solving open-ended problems, and promote an active learning environment, by diffusing multidisciplinary knowledge and engaging collaborations amongst graduate and undergraduate study groups.

References

[1] FHWA, ACTT: A “How To” Guide for State Highway Agencies, US Department of Transportation, 2005.

[2] Borrego, M., and Newswander, K.L., (2008). "Characteristics of Successful Cross-Disciplinary Engineering Education Collaborations," Journal of Engineering Education, Apr2008, Vol. 97 Issue 2, p123-134, 12p.

[3] Wulf, W.A., (1998). "The Urgency of Engineering Education Reform," The Bridge Vol. 28, No 1,1998, pp. 4-8.

[4] Dym, C.L., Agogino, A.M., Eris, O., Frey, D.D., and Leifer, L.J., (2005). "Engineering Design Thinking, Teaching, and Learning," Journal of Engineering Education, January 2005.

[5] Prince, M.J., and Felder, R.M., (2006). "Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases," Journal of Engineering Education, April 2006.

[6] Waston, K., (2009). "Change in Engineering Education: Where Does Research Fit?” Journal of Engineering Education, January 2009.

[7] Waston, K., and Froye, J., (2007). "Diversifying the U.S. Engineering Workforce: A New Model," Journal of Engineering Education, January 2007.

Appendix A. The Group Project

CEGR 6090 Nondestructive Testing
ETCE 4251 Highway Design and Construction
Fall 2010

Team Project

For teams of three people:

1) Identify an Accelerated Construction Approach as outlined in the class notes.

2) Conduct literature review on the State-of-the-Art of the Approach.

3) Design a monitoring system/approach for an imaginary system (for example, a 2 mile highway pavement or a bridge).

4) Write a summary report not more than ten pages that includes:

1. Description of the system design
2. Description of the system application
3. Description of what it would take for you to actually put such a system together
4. Description of what obstacles that you might face in the design/use of the system
5. Description of the benefits your system can contribute to the US infrastructure issues

5) Draw a Schematic Picture of how your team envisions how the system would work.

Due on: 10/14/2010