THE IMPACT OF EXPERIMENTAL ENGINEERING PROJECTS ON UNDERGRADUATE RETENTION

T. Hao¹ and A. Alroomi¹

ABSTRACT

The purpose of this work is to improve undergraduate retention rate through hands-on experimental projects. These projects are designed using plug-and-play instruments with step-by-step procedures that do not require students to have strong background in engineering majors. The freshman- and sophomore-level students with fundamental calculus and general physics courses should be adequate for the projects. Studies show that the passive tuned mass damper (TMD) may reduce the seismic response of buildings. In the projects, students assembled various building models with, and without dampers to observe their dynamic responses on a shaking table. The effectiveness of the passive TMD for buildings were evaluated using the experimental data from the tests. The instructors guide students in group discussions about building modeling and earthquake safety through simple physics. An overview of fundamental seismology, including sources of earthquakes, propagation of seismic waves, and earthquake impacts to urban environment were introduced to the participants. Students also learned the fundamental concepts of earthquake resistant design through various scaled building models. Through intuitively hands-on learning experiences students were engaged to basic engineering problem-solving steps from the issue discovery, problem identification (convert to a solvable engineering and science project from a real-life issue), solution plans, implementation, analysis and interpretation. At the end of the projects, students gained interest in earthquake building safety, built and tested instrumented models, and collaborated in teams. These projects enhanced students’ engagement to engineering and helped them to establish a strong sense of belonging in peer groups, and will ultimately improve the undergraduate engineering retention rate.

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The purpose of this work is to improve undergraduate retention rate through hands-on experimental projects. These projects are designed using plug-and-play instruments with step-by-step procedures that do not require students to have strong background in engineering majors. The freshman- and sophomore-level students with fundamental calculus and general physics courses should be adequate for the projects. Studies show that the passive tuned mass damper (TMD) may reduce the seismic response of buildings. In the projects, students assembled various building models with, and without dampers to observe their dynamic responses on a shaking table. The effectiveness of the passive TMD for buildings were evaluated using the experimental data from the tests. The instructors guide students in group discussions about building modeling and earthquake safety through simple physics. An overview of fundamental seismology, including sources of earthquakes, propagation of seismic waves, and earthquake impacts to urban environment were introduced to the participants. Students also learned the fundamental concepts of earthquake resistant design through various scaled building models. Through intuitively hands-on learning experiences students were engaged to basic engineering problem-solving steps from the issue discovery, problem identification (convert to a solvable engineering and science project from a real-life issue), solution plans, implementation, analysis and interpretation. At the end of the projects, students gained interest in earthquake building safety, built and tested instrumented models, and collaborated in teams. These projects enhanced students’ engagement to engineering and helped them to establish a strong sense of belonging in peer groups, and will ultimately improve the undergraduate engineering retention rate.

Introduction

Recent studies [1, 2] point out an average of 40 to 50 percent of engineering students nationally switch to other majors or drop out. Some schools reported losing up to 70 percent of women and underrepresented ethnic minority students. Research shows that the first two years are often crucial to student retention and eventual success. In additional, lecture courses generally have

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been found to be less effective than active learning. As a result, freshman and sophomore curricula have been revamped at a number of schools to incorporate hands-on projects, student research, rapid instructor feedback, class discussions, and teamwork. This work aims to develop hands-on projects to engage students with research experiences in the first two years, to strengthen students’ skills for academic success, to increase student’s interest to further engage in research activities, to enhance student’s self-efficacy for completing a baccalaureate degree in engineering, and ultimately pursuing an engineering career.

**Overview of Experimental Research Projects**

Understanding the effects of earthquakes on structures is a fundamental subject to the civil engineering community in California. Our goals of the hands-on projects are to introduce freshman- and sophomore-level students to awareness of seismic activities, to foster creative problem-solving techniques with an emphasis on working in teams, and to help students see themselves as engineers and feel they belong in engineering. This section presents a sample project on experimental learning which focuses on structural/earthquake engineering to understand the vibration response of a building subjected to the ground motion.

Three students, the cohorts of the Attract, Inspire, Mentor and Support Students (AIMS) program at California State University Northridge’s College of Engineering and Computer Science, participated in the project. One of the primary mission and goals of the program is to increase the number of underrepresented minorities (including Latinos, Women, and other economically disadvantaged students) who successfully transfer from community colleges to California State University Northridge (CSUN), to pursue majors in Engineering and/or Computer Science. One of the participated students has completed all lower-division course work and transferred to CSUN. Two others have another year in the community college before transfer. They all completed the first-year fundamental calculus and general physics courses.

The project duration was about ten weeks in Summer 2017, two meetings per week and three hours each meeting. Lectures were prepared with PowerPoint slides and videos, and were delivered in 30 to 45 minutes in selected meetings to provide the description of the activities, relevant concepts, and required equations. Since the main goal of this team project is to encourage students to grasp the building behavior during seismic events, the complicated mathematical derivations were not presented but provided as reference materials.

The students discussed and came up with the problem statement and objectives of the project. Their mission is to use a tuned liquid damper (TLD) to reduce the vibration response of the building in mathematical and experimental model [3]. A four-story model with a base of 126 mm by 141 mm was placed on a shaking table which is used to simulate earthquake ground motions. Also, a function generator, attached to the shaking table, was used in order to increase or decrease the vibration amplitude and frequency of the shaking table (see Fig. 1). A motion sensor was used to record the displacement of the building due to vibration. The building parameters were evaluated and the natural frequencies and mode shapes of the theoretical model were calculated.
During the experiments, the student team faced some difficulties and resolved them. For instance, the team evaluated the information found on open web-resources in order to convert the equivalent floor weight of the building. Another example is that the building model’s base was lifted during the vibration simulation, which contradicted the assumption that the building is fixed to the ground. To solve this problem, the student team used a stiff board to hold the base in place in order to proceed with the experiments.

The experiments and observations were conducted in two parts: with and without using a tuned liquid damper. The experiment started first without the tuned liquid damper, the structure was tested with the frequencies of shaking table from 0.8 Hz to 10 Hz. Once the testing data were gathered, a rough estimation of the building’s natural frequencies were obtained, and then compared with the theoretical results. The model was tested again with a water tank as tuned liquid damper. In order to find out whether the location of the water tank will make a difference or not, the tank was place on the first-, the third-, and the roof-level, respectively. The results are compared at the end of the study to find out the efficiency of tuned liquid dampers. This project enhances data gathering and discussion of experimental versus theoretical results.

The ten-week project was concluded with poster and oral presentations, both internally to CSUN community during the AIMS² Student Research Symposium and externally during HENAAC Conference. Through this experience students developed research skills such as

- an ability to evaluate information found on open web-resources,
- an ability to develop and refine good questions to get needed results,
- an ability to display persistence by continuing to pursue information to gain a broad perspective,
- an ability to use interpersonal relationship to gather and share information.

**Assessment Plan and Future Work**

The assessment questionnaires were not available at the end of this project due to time constraints. In the future, both quantitative and qualitative assessments are planned. Table 1 shows a sample questionnaire which will be given in both the pre- and post-project surveys to compare the research skills learned from participating team based projects.

Table 1. Sample questionnaire comparing the confident level through the pre- and post-project surveys.

<table>
<thead>
<tr>
<th>A. How confident are you?</th>
<th>Very confident</th>
<th>Somewhat confident</th>
<th>Not too confident</th>
<th>Not at all confident</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1 I feel confident in identifying issues to be solved.</td>
<td></td>
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<tr>
<td>A.2 I feel confident in preparing research scope.</td>
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<td>A.3 I feel confident in evaluating information found in open web-resources.</td>
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<td>A.4 I feel confident in developing/conducting an experiment.</td>
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<tr>
<td>A.5 I feel confident in working in a group.</td>
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<tr>
<td>A.6 I feel confident in creating a slide/poster presentation.</td>
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<tr>
<td>A.7 I feel confident in making an oral presentation.</td>
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</table>

The assessments will focus on
- whether the project provided significant knowledge of the engineering theories,
- whether students gained research skills,
- student satisfaction with the project,
- overall usefulness of the project, and
- whether the gains result in improved academic performance.
Conclusions

During this ten-week project, the students became more self-motivated through team meetings, more efficiently gathered relevant information through research on open web resources, and more proficiently used engineering software and spreadsheet for problem solving. Based on informal feedbacks from the students, our experimental project did show positive impact to students on their interest in engineering topics, and increasing self-confidence to succeed in their engineering curriculum.

The technical content of the experimental project is to be documented with detailed description of the activities, objectives and outcomes, experiment set-up instructions, and assessment results. These documents may be used to promote implementation of the team-based freshman and sophomore curricula.

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References

