College Industry Partnership in Engineering Technology Education

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Abstract
In today’s engineering education, challenges exist to motivate and educate students from the millennial generation, such as closing the gap between 21st century workplace demands and a 21st century education, enhancing students’ passion for learning and commitment to lifelong learning, better infusing 21st century skills into the classroom, and so on. Among various high impact practices and educational technology, real world problems and hands-on experience are efficient approaches to improve the learning experience of engineering technology students. In this paper, a college industry partnership was established through Industrial Advisory Board. Major course curricula are reviewed periodically at Industrial Advisory Board meetings. “Shock and Vibration Analysis” class was recommended to revise lab contents following industrial standards. Course instructor showed Industrial partners the vibration lab equipment and the procedure to run a vibration course lab. Course instructor and industrial partner collaborated on the lab revision plan. Three vibration systems were then designed and fabricated by industrial partner. After the establishment of the new systems, a presentation on the mechanisms and applications of various types of industrial acoustic sensors was given first by an industrial expert. Then student’s lab experience was supervised by both course instructor and industrial partner, in which students were provided the on-site guidance on the instrumentation used in industry and how to interpret such instrumentation. Requirements on how to write a professional lab report were also explained. Through such collaboration, not only students are able to experience a real industrial measurement, but also industrial partner can be exposed to and recognized by academia and has possible future employees better trained. In this paper, activities to improve such collaboration and expand it to other classes in the future are also discussed.

Introduction
High impact and innovative teaching practices have been extensively studied in engineering undergraduate education [1-8]. Traditionally, such practices may include relating classroom knowledge to real world problems, emphasizing hands-on experience, applying active learning strategies, integrating faculty research activities into course teaching, encouraging students to apply learned knowledge to work and research experience, and utilizing various approaches to get student feedback. Although these practices have been approved to be effective approaches and can increase student motivation and involvement, challenges still exist and emerge for the education of the millennial generation [9-15]. The main challenges may include
how to increase student engagement, how to close the gap between workplace demands and engineering education, how to enhance students’ commitment to lifelong learning, and how to better infuse 21st century skills into the classroom. As a result, new teaching strategies are necessary so that faculty can have deeper understanding of students and can develop more confidence in working with today’s students. Such new strategies will help the transformation and adoption of high impact educational technology, and deepen faculty’s passion for teaching and the process of learning.

Collaborations between faculty and industrial partners can be an efficient approach to improve engineering technology education [16-20]. Such collaborations may include collaborative lab delivery, student research mentorship, senior design project supervision, etc. Such collaborations can not only get faculty familiar with resources available on and off campus, but also make it possible for faculty to share best practices with each other. Furthermore, through collaborations, a faculty can serve as agent for change in his or her department. For example, a faculty can assist colleagues through instructional coaching method, and can also develop a plan sensitive to his or her department’s needs. Overall, such collaborations can help to support faculty’s teaching excellence and to create a community across departments on campus.

**SUNY College at Buffalo Mechanical Engineering Program Industrial Advisory Board Background**

The mission of Mechanical Engineering Technology (MET) Program at SUNY College at Buffalo is to prepare students for careers in engineering technology that includes engineering principles, practical experience and an educational foundation so that students can succeed professionally, intellectually and responsibly. The program has established three educational goals: (1) To instill in students a classroom/laboratory basic education in mechanical engineering technology fundamentals. (2) To develop in students the skills required to apply engineering fundamentals to the analysis, synthesis, and evaluation of mechanical engineering technology problems. (3) To foster in students personal development to ensure a lifetime of professional success and an appreciation for the ethical and social responsibilities of a mechanical engineering technologist and a world citizen.

One program constituent - recent graduates and employers of these graduates - are directly responsible for developing and maintaining the program educational objectives. In practice, their interests are represented by members of the program’s Industrial Advisory Board (IAB); several of these members are in fact graduates of the program or engineering managers who employ graduates. Thus, the IAB is well-positioned to ensure that the objectives meet the needs of the graduates and employers. Generally, the IAB meets with program faculty twice per year. At the meetings, any member is free to propose a topic for consideration. Discussion of the program educational objectives can be triggered by a professional concern (changing requirements in the workplace) or an administrative concern (evolving practice in writing outcomes and objectives).

At IAB meetings, MET program major courses are reviewed and revised periodically. In spring 2018, industrial representatives pointed out that the student’s capability to perform professional vibration analysis need to be improved. To realize this goal, IAB decided that ENT 402 “Shock and Vibration Analysis” lab contents should be revised to keep MET students engaged with industrial measurements and to provide students with team-oriented lab activities following industrial standards.
Course Lab Revision Plan

PCB Piezotronics is a company located in Buffalo, NY area and has been an employer of Buffalo State graduates. The company is a world leader as a manufacturer of piezoelectric quartz sensors, accelerometers, and associated electronics for the measurement of vibration. The company makes more than 700 different types of sensors and accessories for almost every range of measurement.

At spring 2018 IAB meeting, a tour of MET program labs was given to PCB Piezotronics representative to show the lab equipment and apparatus utilized in ENT 402 class. After the meeting, collaborations between a PCB Piezotronics R&D engineer with certified experiment experiences and ENT 402 instructor was established to revise the course lab experience.

The overall course lab revision plan can be summarized as follows:

- ENT 402 instructor will define the contents of lab revision and will introduce necessary theoretical background in classroom before students perform a revised lab.
- PCB Piezotronics engineer will design and construct a new vibration lab system.
- PCB Piezotronics engineer will give a lecture on vibration sensors - principles, selection, installation, measurements, data collection and analysis, etc.
- PCB Piezotronics will donate sensors, lab equipment and software to Buffalo State.
- PCB Piezotronics engineer and ENT 402 instructor will oversee a round of lab together and then will further revise and improve student’s lab experience.
- ENT 402 instructor will document lab instructions so that other instructors will be able to run the lab in the future.
- ENT 402 instructor will report back to IAB members the outcomes of the collaboration. IAB members will then decide how to expand such collaboration to other classes and labs.

Through such collaborations, MET program will receive discounted/free lab equipment and be able to provide students relevant cutting-edge industry knowledge. In the meantime, PCB Piezotronics can have its company’s name exposed and recognized in academia and industry as an unofficial “sponsor”, and have its possible future employees better trained at college.

Old Vibration System Setup

ENT 402 class has three labs each semester. In each lab, students usually are divided into three groups (about 8 people each group), then each group perform a lab on a specific time. If multiple lab systems are available, one group will be further divided into sub-groups. In ENT 402, one lab experience is to measure beam vibration, in which vibration data is recorded and collected on a digital microscope, and then transferred to and further analyzed with Excel on a computer.

Figure 1 shows the beam vibration system setup before spring 2018. One end of the vibration beam is fixed by a vise and the other end is attached with a broadband sensor. The vibration signals from the sensor are amplified by a signal coupler and then transferred to and displayed on a digital oscilloscope. The signals on the oscilloscope can be further transferred to a computer and then analyzed with signal analysis software. Typical vibration signals are shown in Figure 2.
Theoretically [21], the natural vibration frequency $f$ of a beam can be calculated according to Equation 1.

$$f = \frac{1}{2\pi} \sqrt{\frac{3EI}{(33 \frac{m + m_{sensor}}{140})l^3}}$$  

(1)

Where $E$ is material elastic modulus, $l$ is beam vibration length, $m$ is the mass of beam, $m_{sensor}$ is the mass of sensor, and $I$ is the area moment of inertia of beam and is defined by Equation 2.

$$I = \frac{1}{12} bh^3$$  

(2)

Where $b$ is the width of beam and $h$ is the thickness of beam.

The mass of beam can be determined according to Equation 3.

$$m = \rho bh l$$  

(3)

Where $\rho$ is the density of beam.

Table 1 summarizes the experimental parameters. The theoretical frequency value 27 Hz, which is calculated according to Equation 1, generally agrees with the experimentally measured value 28 Hz. During the lab, the beam vibration length $l$ can be adjusted to change beam vibration frequencies.

<table>
<thead>
<tr>
<th>b (m)</th>
<th>h (m)</th>
<th>l (m)</th>
<th>$\rho$ (kg/m$^3$)</th>
<th>E (N/m$^2$)</th>
<th>$m_{sensor}$ (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.025</td>
<td>0.0033</td>
<td>0.03</td>
<td>7850</td>
<td>$2.1 \times 10^{11}$</td>
<td>0.015</td>
</tr>
</tbody>
</table>
New Vibration System Design and Test

Pre-lab Presentation

Before a vibration lab is performed, a presentation was given to students by PCB Piezotronics engineer on vibration measuring techniques. The fundamental theory of piezoelectric effect was introduced. The design and mechanisms of various types of piezoelectric sensors, including accelerometer, dynamic force transducer, and dynamic pressure transducer were explained. The signal conditioning technique was presented. The analyses of sensor signals in both time domain and frequency domain were carried out. The importance and influence of various mounting techniques on measuring frequencies were emphasized.

Vibration Beam Structure Design

Based on the lab guidelines defined by ENT 402 instructor, PCB Piezotronics designed and constructed a new vibration beam structure as shown in Figure 3 and 4. The structure consists of four components: beam, base, clamp and post. Figure 5 and 6 show the engineering drawing of beam and post with dimension unit in inches.

![Figure 3: AutoCAD design model of vibration beam structure](image1)

![Figure 4: A picture of vibration beam structure](image2)

![Figure 5: Beam engineering drawing](image3)

![Figure 6: Post engineering drawing](image4)

The theoretical vibration frequency $f$ of the beam can be calculated according to Equation 4 [21].

$$f = \frac{3.52}{2\pi} \sqrt{\frac{EI}{ml^3}} \quad (4)$$
Where \( E \) is material elastic modulus, \( l \) is beam vibration length, \( I \) and \( m \) are defined according to Equation 2 and 3, respectively.

The theoretically calculated vibration frequency \( f \) is 78 Hz based on dimensions in Figure 5.

**Sensor Selection and Setup**

In the new vibration system, two sensors are applied as shown in Figure 7. One sensor is embedded in the impact hammer and is used to measure the force applied to hammer. The other sensor is attached to the free end of the beam by glue to measure the beam vibrations. A dual-channel ICP® (IEPE) digital signal conditioner, as shown in Figure 8, is used to transfer sensor signals to a laptop. The hammer sensor is connected to channel 2 and the beam sensor to channel 1. Figure 9 and 10 shows typical signals from the hammer and beam, respectively.

![Figure 7: A picture of impact hammer with embedded sensor (top) and beam vibration sensor and couplant (bottom)](image1)

![Figure 8: A picture of dual-channel ICP® (IEPE) digital signal conditioner](image2)

![Figure 9: Typical hammer force signals](image3)

![Figure 10: Typical beam vibration signals](image4)

**New System Setup and Test**

The final system setup is shown in Figure 11, where the PC based Soundcard Oscilloscope software is used to collect, display and analyze vibration signals. The software parameter setup interface is shown in Figure 12, where trigger mode is single and trig resource is Channel 2, and signal input setting is digital signal conditioner.

The experimentally measured beam vibration frequency is about 58 Hz, which is different from theoretical value 78 Hz. This may be caused by several factors, including the boundary
condition at the beam clamping end, the interference of higher natural vibration modes, and the application of couplant.

Figure 11: A picture of final system setup  
Figure 12: Typical software setup interface

New Lab System Summary and Future work

A total of three new vibration systems were constructed by PCB Piezotronics. Each new system consists of three major components: vibration beam structure, signal conditioner and PC based oscilloscope, which replace the vibration beam, signal coupler and digital oscilloscope in the old vibration system, respectively. The design and test of the new system follows corresponding industrial standards. The new lab experience provides students the opportunities to learn how to perform industrial vibration measurements, select appropriate sensors depending on the type of structures, decide and apply suitable sensor mounting techniques to improve measurement accuracy, set up data acquisition system parameters and analyze vibration data, and how to write a good and professional lab report.

At the time being, the theoretically calculated vibration frequency is 78 Hz and the experimentally measured vibration frequency is 58 Hz. The main reason for this difference is because the beam clamping end in the new system is not a perfect fixed-end boundary condition. Other reasons may include the interference of higher natural vibration modes, which has been verified during experiments by hitting the vibration beam at various locations, and the influence of sensor couplant. In the future, this error can be corrected by modeling the system in an AutoCAD software (as shown in Figure 3) and then use finite element techniques to simulate beam vibrations more accurately.

Conclusions

In this college industry partnership, course curriculums were reviewed periodically at IAB meetings to satisfy MET program educational goals. ENT 402 “Shock and Vibration Analysis” course curriculum was recommended to be revised to keep students engaged with industrial vibration measurements. A plan for the collaboration between PCB Piezotronics and SUNY College at Buffalo was proposed. A presentation on current industrial vibration measuring techniques was given by a PCB Piezotronics engineer. Three vibration systems were designed and constructed by PCB Piezotronics and were donated to SUNY College at Buffalo. Both PCB Piezotronics engineer and ENT 402 instructor supervised student lab experience. Through such labs, students are able to perform real-world vibration measurements following industrial standards, and learn how to select sensor, set up a vibration system, collect and analyze experimental data, and write a professional lab report. At the time being, this partnership is being
reported to and reviewed by IAB members. In the future, such collaborations will expand to other courses, such as finite element analysis technique in engineering design, pressure measurement in fluid mechanics, and temperature measurements in thermodynamics and heat transfer courses.

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References


**Keywords**

Undergraduate education, engineering technology education, college industrial partnership