# AC 2009-2144: INDUSTRY–STUDENT PARTNERSHIPS IN DEVELOPMENT AND SHARING OF EDUCATIONAL CONTENT INVOLVING LABVIEW

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Andrew joined NI in 2000 as an applications engineer moved quickly through jobs as team lead and team manager. In 2002 he left Austin and served as a field engineer in Richmond, Virginia covering various parts of the Commonwealth. In 2005 he began working with 25 Universities from Virginia to Massachusetts to Illinois. In 2000, after working throughout his 7 year collegiate career at Delco Electronics in Flint, MI, he received a Bachelor of Science in Engineering-Physics and a Bachelor of Music-Education from the University of Michigan.

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# Industry–Student Partnerships in Development and Sharing of Educational Content Involving LabVIEW


## Abstract

The biomedical engineering (BME) students at our university often need hardware and software for data acquisition, automation and data analysis for their instrumentation laboratory classes and open-ended design projects every semester. We have teamed with the Education Division at National Instruments to form a collaborative partnership for the necessary resources and to create teaching material to facilitate students with their design projects. National Instruments have donated NI ELVIS system instrumentation equipment during the 2007–2008 academic year as well as continuous support to help students with their learning objectives. Since the students work on a number of diverse projects each semester their requirements vary. In order to meet their needs, we have a student-initiated supplemental training curriculum to train BME students on basic and advanced LabVIEW programming and a variety of other topics. The content of the instructional materials for the training is inspired by problems students encounter when working on their semester design projects. Many advanced students have volunteered to be Student Facilitators (SFs), who take the responsibility for the development and implementation of the instructional materials, which are provided in a seminar format. The supplemental curriculum that has been developed addresses a wide variety of topics and is chosen based upon student feedback. The use of students as teachers has resulted in a higher rate of acceptance of the material and minimizes the costs of providing the training. The hands-on seminars are offered to a wide range of the student body of the College of Engineering, including freshmen to graduate students, and emphasizes the mentoring of younger students by the older, more experienced students. The SFs are asked to evaluate the learning outcomes of the seminars they facilitate both qualitatively and quantitatively by creating and administering both pre- and post-seminar surveys. The surveys are designed to measure understanding of basic knowledge as well as any increases in student skill levels when using LabVIEW. After the SFs create, develop and evaluate the teaching materials and learning outcomes, National Instruments would then able to post the material on their website to enable other universities to utilize the content. Additional collaboration is planned between our university, National Instruments and the upcoming biomedical engineering department at The Hanoi University of Technology, Vietnam to provide their students with the organizational framework, teaching materials and instrumentation equipment necessary to teach LabVIEW. This paper will discuss the teaching material created by the SFs, the evaluation of the learning outcomes, and the benefits of the industry–student partnership to enhance student learning.


## I. Introduction/Background

Instrumentation is an integral part of the Biomedical Engineering curriculum as it teaches the student how to select appropriate devices for electronically measuring the biomedical phenomena. At the University of Wisconsin-Madison, two courses in bioinstrumentation are offered on an annual basis. BME 310, *Introduction to Biomedical Instrumentation* is a required, core course in the undergraduate Biomedical Engineering program geared towards sophomore students, while BME/ECE 462, *Medical Instrumentation* is an advanced course intended for seniors and first-year graduate students [1-2]. BME 310 is offered to around 40 students each spring, while BME/ECE 462 is offered to around 20 students each fall. Each course has a laboratory component which plays an important role in understanding the material covered in lecture. In addition, BME undergraduates, around 70 students each semester, take several semesters of design courses (BME 200/300/400) to gain experience designing biomedical devices, and routinely use equipment available in the biomedical teaching lab during these projects[3].

The wide availability of personal computers has led to the development of computer-based instrumentation. With PCs, sensors can be integrated with software to enhance the educational experience of the student. National Instrument's LabVIEW software provides a platform for seamlessly integrating hardware with data processing software. In past semesters, we have experimented with using the ELVIS board and LabVIEW in the labs donated by National Instruments. This combination of NI products has allowed students to gain hands-on experience with both hardware for data acquisition and software for real-time data processing. Digital acquisition of the data allowed students to explore algorithms for data manipulation as well as appreciate mathematical concepts such as the Fourier transform, sampling theory and others[1-2].

In addition to these instrumentation classes, students taking BME design classes often develop custom instrumentation[3]. These solutions often require a mixed software/hardware components. The LabVIEW/ELVIS setup provides an environment for prototyping these devices. Based on our experiences from the past semesters, we observed that the students have found the LabVIEW/ELVIS setup to be of immense help. We have provided instructions for using this setup on the BME website so all students can use these machines as they need them[1-2]. During the process, teaching assistants and the NI support on-campus have provided the necessary technical support.

## II. Supplemental Training Curriculum

The BME design course (BME 200/300/400) is offered to provide students with an opportunity to work in a team on a client-centered biomedical engineering design projects. The students get a first-hand experience in designing and building prototypes, and integrating engineering and life sciences to solve biomedical engineering problems[3]. The students work on a wide variety of design projects for which the technical skill requirements vary from semester to semester. We observed that the students have not necessarily learned all the technical skills from their classes which are required for fabricating a prototype.

We identified the need to implement a supplemental training curriculum with a *"just-in-time"* approach to help the students with their design projects. The supplemental training curriculum was implemented in collaboration with the teaching team for "Introduction to Engineering Design" (InterEgr 160) course offered to prospective freshmen engineering students[4-8].The goal of the supplemental training curriculum is to provide BME/InterEgr 160 students with hands-on training in areas such as electrical/electronics, programming (LabVIEW, CAD and microcontroller), machining and fabrication to help them succeed with their design projects[4, 7].

The supplemental training curriculum is a students-initiated effort with the goal to provide academic help and technical support to fellow students with their design projects. We integrated the three core principles from the Delta Program which are Teaching-as-Research, Learning-through-Diversity and Learning Community during the implementation of the supplemental curriculum[9]. In the Teaching-as-Research phase we designed the contents of the instructional material for the training inspired by the problems faced with their design projects in the past and are currently facing. A Kaizen-based strategy for continuous improvement in the educational content of the instructional material was implemented based on the regular informal feedback from the students regarding the problems they face with their projects[8]. The students work on a wide range of projects which require variety of skill sets. By providing training on diverse topics, we promoted learning for students through diversity in training curriculum. These supplemental training sessions were attended by freshman students to graduate students, it provided an opportunity for students at different academic levels to come together and learn from each other. It helped in the formation of learning communities where the students not only learn from the instructor but also from the peers. Hence it promotes peer-to-peer learning and allows individuals to come together to achieve their learning goals[7].

Since the supplemental training curriculum was initiated by students, many advanced students volunteered to be the Student Facilitators (SFs). These SFs participated in the development of the curriculum based on the problems they faced during their design projects. They also took continuous informal feedback from the students to identify the topics that need to be included in the curriculum. Thus a *just-in-time* approach was implemented, which took into consideration the current needs of the students and designed the curriculum accordingly. Many of the SFs also took leadership roles to organize and teach these training sessions. The use of students as teachers resulted in promoting mentoring of inexperienced students by more advanced students, higher rate of acceptance of the material and also minimized the cost of providing the training[6-7, 10-11].

## II. LabVIEW Activity

We organized two LabVIEW training sessions through the supplemental training session. The first session was dedicated to provide students with a basic understanding of LabVIEW and familiarize them with the LabVIEW software, while the second session was dedicated for advanced LabVIEW training[4].

### Activity I: LabVIEW basics

The first half of this laboratory activity familiarized the student with the software package LabVIEW from National Instruments for data acquisition and virtual instrumentation. The student built and tested electronic circuits such as a voltage follower and in the process got acquainted with the NI Educational Laboratory Virtual Instrumentation Suite (ELVIS) system. In the second half of this laboratory activity the students worked on advanced LabVIEW concepts. They created sequence and case structures for controlling NI ELVIS variable power supply and in turn power peripheral elements such as LEDs using transistor[4].

### Activity II: Advanced LabVIEW

In the first half of this laboratory activity the student learned the basic principles of state machines using LabVIEW. The state machines they build taught them decisions-based programming depending on the flow of logic. In the second half of this laboratory activity was designed to teach the students the basic principles of control systems. The students will build a voltage divider circuit using any combination of resistors. The LabVIEW hardware/software supplied a known starting voltage through the NI ELVIS and the voltage drop across one of the resistors was measured. The goal of the software was to get the measured voltage within 5% of a voltage set-point. This was accomplished by using feedback to make changes to the original supply voltage. First, a simple case was performed, where the voltage was lowered if the measured value was higher than the set-point, and the voltage was increased if the measured value was lower than the set-point. Upon completion of this, the students were taught other control algorithm used to provide proportional control to the feedback circuit[4].

## III. Evaluation and Results

We present the data from the pre and post surveys collected for the first training session on LabVIEW basics.

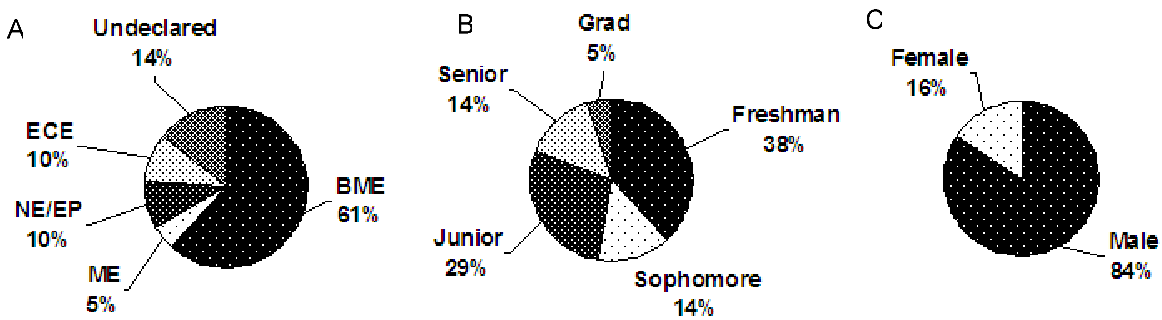


Figure 1 The distribution of A. students enrolled in different majors, B. academic levels of the students an C. gender distribution of students attending the LabVIEW basics training session.

As expected, the majority of students attending the seminar were biomedical engineering majors as seen in Figure 1A. Both the usefulness of LabVIEW for data acquisition from medical instrumentation and the direct applicability of LabVIEW to classes within with BME curriculum account for the high interest among biomedical engineering students. Figure 1B show that the interest in the seminar was well distributed from freshman to graduate level, showing a widespread appeal to students at all levels of their academic careers. Participation by gender is shown in Figure 1C and as expected reflects the greater percentage of males enrolled in the College of Engineering.

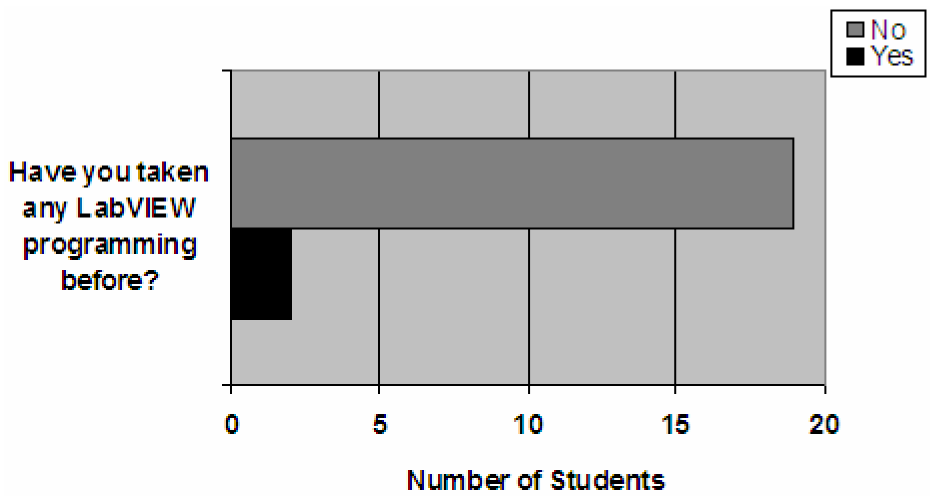


Figure 2 The number of students with prior LabVIEW experience

As displayed in the graph above, 19 of the 21 students had no prior experience using LabVIEW graphical programming software. The lack of experience or familiarity with the programming experience calls attention to a large gap between the resources and training available to students for use. LabVIEW is available for student use in multiple laboratories across the College of Engineering campus, however many students are unaware of its presence. Generally speaking, students are uninformed about the software's capabilities and untrained in its use. This deficit highlights the strong need for offering supplemental training on the use LabVIEW.

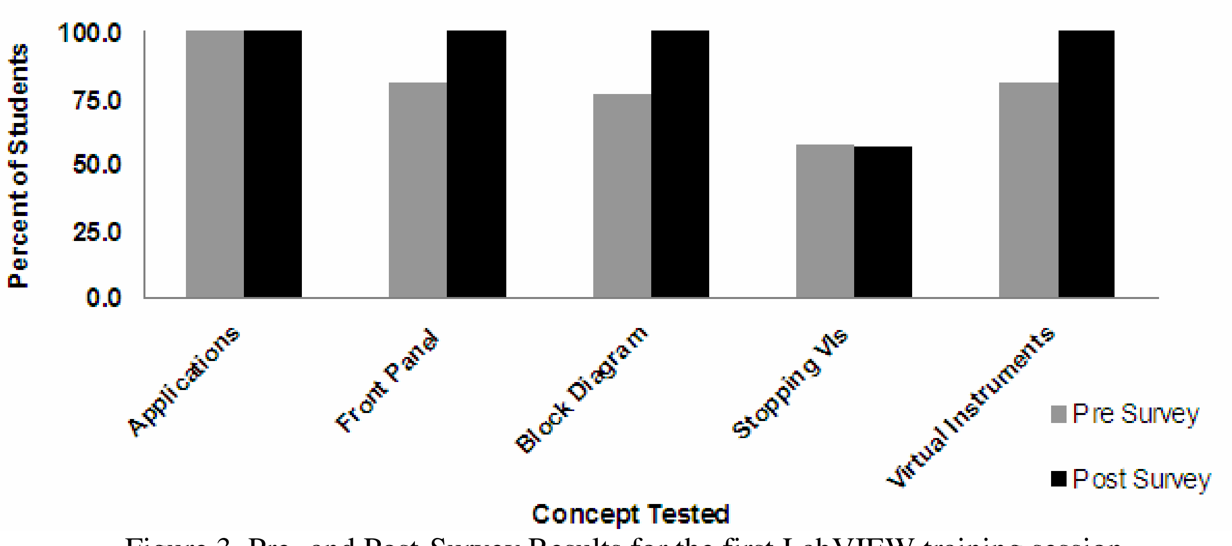


Figure 3 Pre- and Post-Survey Results for the first LabVIEW training session

Figure 3 displays the learning gains achieved during the seminar. As shown, the number of students answering correctly for each question improved or stayed the same for all but one question. Additionally, the high level of understanding was widespread; every student attending the seminar was able to correctly answer each question on the survey, with the exception of the question on *'stopping virtual instruments'*. Investigation of the curriculum revealed that this topic was not sufficiently taught. As a result, future seminar facilitators will be able to improve their instruction to better address this concept.

## IV. Conclusion

The collaboration between the NI and the BME department at the University of Wisconsin-Madison has been beneficial to both of them. The instrumentation laboratory at the BME department has received technical support and resources in form of hardware and software in order to teach data acquisition, automation, data analysis and other concepts to the students. Through the supplemental training curriculum we have been able to teach basic and advanced LabVIEW programming concepts to a larger audience from freshman to graduate students. A number of students have identified themselves as SFs and took the initiative to develop LabVIEW-based instructional material based on their previous experiences with the design projects. Similarly a number of SFs took the role as teachers to teach these concepts to fellow students. This peer-to-peer learning process has helped in the formation of Learning Communities, wherein students can communicate with other students to solve the problems they face in their design projects. In return the NI has benefited by having access to all the teaching and learning material developed by students posted on the web, which they can distribute to other institutions to further their learning goals.

## V. Future Work

We plan to improve on the basic and advanced LabVIEW seminars based on the student feedback. We also plan to introduce couple advanced topics such as NI LabVIEW-based FPGA programming and ARM microcontroller programming in future.

The Hanoi University of Technology (HUT), Vietnam is in the process of setting up the new BME curriculum based on the BME department at the University of Wisconsin-Madison. The new BME curriculum designed by HUT would include courses such as BME 310, BME 462 and BME 200/300/400, similar to ones taught at our university. We help them build their laboratory curriculum by establishing collaboration between NI and BME department at HUT and by providing them with necessary framework to develop their laboratory and design courses.

## VI. Acknowledgement

We thank all the BME students who have participated in preparing the instructional materials and assisted in teaching these training sessions. We would like to thank the BME department and National Instruments for providing continuous support, resources and encouragement. We would also like to thank faculty members affiliated with the DELTA program, the College of Engineering and the CIRTL[12] group at our university for their continued support (NSF Grant No. 0227592).

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## Appendix I

### Pre- Seminar Survey

Name: ______________________ Major: _____________ Engineering/undeclared

Year: _______________________ Male/Female

Are you an INTEREGR 160 Student? Yes/No

Please circle one:

1. Have you taken any LabVIEW programming lab before? Yes/No

2. NI LabVIEW is a graphical programming software for measurement and automation. Yes/No

3. NI LabVIEW programming could be used
a. data acquisition b. instrument/hardware control c. data analysis d. all of the above

4. In a LabVIEW program, the '*Front Panel*' is the graphical interface between the user and the program? Yes/No

5. In a LabVIEW program, most of the graphical programming is done in the '*Block Diagram*'? Yes/No

6. It is okay to stop any running VI by pressing the stop button? Yes/No

7. What does LabVIEW '*VI*' stand for?

a. visible item b. visible information c. virtual instruments d. none

The post- seminar survey was same as the pre-survey with the addition of the question #8 as shown below:

8. In the space below please indicate what other LabVIEW programming concepts you would like to learn in future training sessions?