Do Engineering – Anywhere, Anytime

Mark Walters, Erik Luther, and Julia Dinolfo

National Instruments

Mark.Walters@ni.com, Erik.Luther@ni.com, Julia.Dinolfo@ni.com

Abstract – *The need to create excitement about engineering has never been more critical. Our global community is faced with finding solutions to big challenges such as global warming, the energy crisis, and increasing demands on communications and urban infrastructure. To address these grand challenges, we require future engineers who are capable, innovative and equipped with practical skills in order to navigate from the design constraints to the solution. To encourage development of this practical skill, educators need to find ways to enable students to “do engineering,” anywhere, anytime. The three fundamental restrictions that prevent educators from being able to accomplish this are cost, accessibility to equipment – both in and out of the laboratory – and space and facilities.*

This paper discusses different ways in which educators are helping students connect with the world around them using graphical system design hardware and software technologies that are both affordable and scalable. We discuss flexible, compact, instrumentation platforms and illustrate how universities use this to enhance labs and improve practical experiences. We demonstrate how educators leverage low-cost, student-owned instrumentation hardware to teach concepts in students’ preferred environments, whether that is in the lab, library, or dorm room.

Keywords: Lab equipment, technology, learning, excitement, challenging, innovative, hardware, software, hands-on, NI myDAQ, instrumentation, portable, student-owned, education

1. INTRODUCTION

Engineering enrollment and retention statistics reflect a disturbing trend in North America. Students are overlooking or abandoning a career path in engineering. According to *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, “only 40 to 60 percent of entering engineering students persist(s) to an engineering degree.”[1] The dangerous consequence of these statistics is a shortfall of creative, young innovators for the future who are equipped to meet tomorrow’s grandest challenges. [2]

Instructional laboratories have been an important part of engineering programs to engage students in the course material and prepare them to practice engineering.

The laboratory gives students contact with the real world and connects the theory and context to the application.[3] Through experimentation with hardware and software instrumentation, the student reinforces theory by applying and practicing the concepts. According to Doughty, “practical experiments and projects lie at the heart of the relationship between meaning and understanding.” [4]

One of the barriers facing students is access to the hardware and software tools and technology to enable them to experiment and explore engineering principals. In the past, the cost of the tools made it impractical for every student to own laboratory instrumentation hardware, such as a function generator, oscilloscope and digital multi-meter. In the laboratory environment, student learning may require equipment shared by multiple students at one time due to the size and cost of the equipment. These limitations create a scheduling burden on laboratory managers for each session and restrict students’ access to the tools to provide an individualized learning experience. The scheduling may not allow sufficient time for students to reinforce the theory and to complete the assigned tasks. This paper describes the tools and technologies used to implement a portable laboratory providing students with an individualized, hands-on learning experience and enhance the learning experience.

Figure 1: NI myDAQ Hardware for Students

2. STUDENT OWNED INSTRUMENTATION

To extend hands-on learning and practical experimentation outside of the lab environment and overcome the barriers of cost, time, and space, National Instruments collaborated with engineering educators from 16 universities to develop an instrumentation tool to extend hands-on learning components as part of their instruction. Through the collaboration, requirements were determined for a portable student personal instrumentation device called NI myDAQ. [5, 6]

Figure 2: Students Learning Anywhere, Anytime with NI myDAQ

NI myDAQ is a low-cost, student instrumentation platform. The device is a portable data acquisition (DAQ) platform that gives students the ability to measure and analyze live signals on a computer. Based on NI LabVIEW graphical system design software, the hardware instrument platform includes eight software instruments to measure and control the NI myDAQ device, providing the functionality of a suite of common laboratory instruments, including a digital multimeter (DMM), oscilloscope, and function generator. Students can access all the ready-to-run software instruments to perform experiments and exercises.

In education, National Instruments also provides a lab-ready partner platform in the form of National Instruments Educational Laboratory Virtual Instrumentation Suite (NI ELVIS). Adopted by thousands of universities and colleges worldwide, NI ELVIS delivers hands-on lab experience with an integrated suite of more than 12 of the most commonly used instruments in one compact form factor specifically designed for education. The NI ELVIS and NI myDAQ platforms share a common software experience, and when used by students in lab and at home, it gives a complementary and consistent approach to taking measurements and experience of real world signals. Students can perform the pre-lab assignments at home using NI myDAQ and reuse the same code and files in the laboratory using NI ELVIS to complete the laboratory exercise. [7]

Figure 3: NI ELVIS Hardware Platform for Laboratories

In industry, National Instruments also has considerable experience developing advanced data acquisition devices based on standard PC technologies. NI ELVIS and NI myDAQ are based on this same data acquisition platform, providing high-performance I/O, industry-leading technologies, and software-driven productivity gains designed for engineers and scientists.

3. REINFORCING CONCEPTS THROUGH RELEVANT APPLICATIONS

Based on NI LabVIEW graphical system design software, NI ELVIS and NI myDAQ give educators and students the flexibility to create or customize their own applications. They create a hands-on learning solution for many core concepts throughout the engineering curriculum. Using the graphical programming environment, students can create their own measurement and automation applications to explore concepts such as analog circuits, sensors, and signals and systems.

Figure 4: Elenco myGrid for NI myDAQ

National Instruments and other leading educational tool providers have partnered to bring the relevancy of real-world systems to students worldwide through NI miniSystems, miniaturizations of large-scale

systems that represent relevant engineering applications. From smart grids to dynamometers, air foils to shaker tables, students can experience the use of the theory they are learning in context of systems that fit in the palms of their hands. An NI miniSystem is an external accessory board that plugs into NI myDAQ or NI ELVIS and interfaces with real-world sensors and signals to teach solutions to relevant engineering challenges.

Figure 5: Elenco myGrid Hardware Diagram

For example, with the Elenco myGrid for NI myDAQ, students can learn the concepts of renewable energy and sustainability through systems that fit in the palms of their hands at a cost of less than \$100 USD. An example of such a plant is shown in Figure 2, a small scale power generation plant, which can be used to demonstrate concepts such as energy monitoring and conservation, and smart grids. The system represents the mixture of both fossil fuels, represented by a motor, and renewable power sources, using a solar panel. Students can monitor and control how much energy is provided by each of the power sources based on availability and demand, demonstrated by varying the load of the houses.

Figure 6: NI miniSystem Block Diagram of LabVIEW Code

4. CASE STUDY: ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Circuits and microelectronics courses traditionally treat laboratory projects and homework as separate activities; however, integrating physical measurements into homework assignments can help students appreciate that textbook theory applies to the real world. It helps them experience the limits of mathematical models. Through the usage of affordable, low-cost technology, Professor Ed Doering at Rose-Hulman Institute of Technology extended the practical experience of concepts beyond the constraints of the laboratory and enabled students to learn in their preferred environments.

In the spring 2011, students in the linear circuit course at the Rose-Hulman Institute of Technology used NI myDAQ to accomplish the integration without laboratory scheduling constraints. The students built and experienced real circuit behavior by working at their own pace and were free of the restrictions of time and place of the traditional laboratory.

By solving the problem analytically—simulating the circuit, building the circuit, and taking measurements—students understand the circuit behavior from three independent vantage points. Adding NI Multisim software circuit simulation provides students with a three-way solution process. Using short video tutorials integrated with the problems, students referenced the relevant hardware tools and software techniques to complete the tasks. [9]

As students solved the same problem three ways, they gained confidence in circuit analysis, improved their ability to set up and interpret simulation results, and developed hands-on laboratory and troubleshooting skills. Moreover, they went beyond basic mathematical manipulations to develop deeper insights into the effects of simplified assumptions, device model mismatches, and temperature-dependent behavior.

Students were positive about their experiences, and the lab instructors observed that students asked fewer yet more focused questions than in past offerings of the course. Through survey results, students indicated that working to harmonize the three aspects of the problem elevated their confidence in their own analytical and lab skills. [10]

5. CONCLUSION

In this paper, we discussed the need to provide hands-on instruction to engage students in course material and prepare them to practice engineering. Today, there are three fundamental restrictions that prevent educators from being able to accomplish hands-on instruction for each student, including the overall cost of equipment and resources, student access to the equipment – both in and out of the laboratory – and the available space in

laboratory facilities to provide an individual learning experience for each student.

Using flexible instrumentation platforms such as NI myDAQ, universities are enhancing labs and improving practical experiences. A portable laboratory like NI myDAQ offers students the chance to learn concepts in their preferred environments; provides a supplement to the traditional lecture and laboratory-based course; and bridges the gap between theory and real-world practice through relevant applications and challenges like the myGrid NI miniSystem. National Instruments has partnered with universities and colleges, such as the Rose-Hulman Institute of Technology, to implement a portable laboratory, providing students with an individualized, hands-on learning experience. Students and educators have been positive about the course results using NI myDAQ. Preliminary results have shown an increase in student confidence in their own analytical and lab skills by extending the practical experience of concepts beyond the constraints of the laboratory and creating a deeper understanding of the course material.

[10] Doering, Ed. "Developing Problem-Solving Skills With Simulation and Portable Instrumentation." National Instruments Instrumentation Newsletter 24 (May 2012). 14. Print.

References

- [1] Educating the Engineer of 2020: Adapting Engineering Education to the New Century. Washington, DC: National Academies, 2005. 40. Print.
- [2] L. Jamieson, Engineering Education in a Changing World, International Engineering Consortium, Chicago, 2007.
- [3] Y. Tsvividis, "Teaching circuits and electronics to first-year students", *Proc. 1998 IEEE International Symposium on Circuits and Systems*, vol. 1, pp. 424-427, Monterey, May/June 1998.
- [4] G. Doughty et al, 'Experimentation: how it reinforces self-learning', *Innovative Methods in Enging Educ.*, 43, 1992, pp. 264-269.
- [5] S. Sharad et al, 'Towards Achieving Hands-On Project-Based Learning beyond Laboratories and into the Dorm Rooms', *Transforming Engineering Education: Creating Interdisciplinary Skills for Complex Global Environments, 2010 IEEE*, 2010.
- [6] NI myDAQ, <http://www.ni.com/mydaq/>.
- [7] NI ELVIS, <http://www.ni.com/nielvis/>.
- [8] Elenco myGrid Evaluation Kit for NI myDAQ, <https://decibel.ni.com/content/docs/DOC-22358>.
- [9] Doering, Ed. "Community: Electrical Circuits with NI MyDAQ." *NI Community*. 22 June 2010. Web. 21 May 2012. <https://decibel.ni.com/content/docs/DOC-12654>.