Virtual Instrumentation helps promote International Cooperation in Engineering Education

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Abstract
As Japan faces the challenge of a declining engineering population, educators in engineering must attract, develop, and produce engineers who are ready for innovation and global cooperation in order to maintain the country’s technical advantage. A key approach to engineering education that helps these requirements is virtual instrumentation, the use of customizable software and modular hardware to create user-defined measurement systems. Made productive by a graphical programming environment called LabVIEW, virtual instrumentation provides an open and common platform on which engineers and engineering educators can design experiments, share results, and collaborate with others on projects in laboratory experimentation, research, and design. In this paper, we will examine a few examples of virtual instrumentation in engineering education and international cooperation as well as study the tools that make them possible.

Keywords: Virtual instrumentation, international cooperation, graphical programming

1. INTRODUCTION: The challenge with Japan today and its future engineers, and the requirement for engineering education
It is well known that Japan is among several countries in the industrialized world with a declining population. Despite the fact that it is dependent on innovation to propel its economy, its innovators – the engineers – are also shrinking in population, as a smaller percentage of the declining youth population is choosing to go into science and engineering [1], [2].

Meanwhile, future engineers must prepare for careers in research and industry, where cooperation and collaboration are essential. Japanese engineers are entering a workforce that is more globalized than ever. Many Japanese manufacturing companies have relocated their manufacturing operations overseas, and have kept only their research and development facilities in Japan [3]. Therefore, they need engineers that can not only create great designs, but can also take that design overseas and collaborate with the manufacturing operations that they have relocated there. Engineers need to be able to innovate using the common tools and platforms that the distributed organization is using.

Japanese research facilities remain strong and have kept up in producing top-level results [4]. Advanced research requires international collaboration. So these facilities require scientists and engineers that can cooperate and communicate with those at other research facilities worldwide. Their ideas and works must be shared using a common set of tools and platforms. The engineers must be versed in these.

Therefore, there is a need for an effective way to attract children into science and engineering, and develop their skills so that they can carry them into their careers in industry. Not only should their skills be portable throughout their careers, but they should be able share those skills with scientists and engineers throughout the world, fostering international cooperation for advanced research. Thus, a requirement for engineering education is attracting, developing, and producing engineers that are ready for innovation and global collaboration and cooperation.

2. A key approach for effective engineering education – virtual instrumentation
Over the past decade, an approach called virtual instrumentation has been gaining popularity in engineering education. As defined in Wikipedia, “Virtual Instrumentation is the use of customizable software and modular measurement hardware to create user-defined measurement systems, called Virtual Instruments.” In particular, the use of graphical programming in this approach has been especially popular, thus enabling non-programmers to learn the approach quickly.

Due to the modularity and customizable software, new experiments can be easily created. When a graphical programming tool such as National Instruments’ (NI) LabVIEW is used to design the software for the system, it is particularly easy. So a student is able to focus on the concept at hand, or a lab instructor can focus on designing an experiment that teaches the concept, despite their lack of expertise or experience in traditional programming [5]. More importantly, with the right modular hardware, LEGO among them, children are attracted through the graphical interface to science and engineering.

A student who learns graphical programming with LabVIEW will benefit from those skills later in her career as an engineer or scientist, because LabVIEW is a tool that is widely used in industry and professional research [6], [7], [9]. She can retain or enhance the skills later, as training is widely available with certification levels that are recognized by...
Virtual Instrumentation promotes international cooperation and collaboration

A common platform for system design in engineering education becomes an ideal tool for cooperation, by virtue of its wide adoption and its merits for sharing ideas, which are enabled by some key features in openness and connectivity.

Virtual instrumentation by definition has a highly customizable software component. LabVIEW realizes the customizability by being open to many software standards and models of computation, in addition to the block-diagram approach of the graphical programming model. Other models such as state diagrams, text input, math scripts, and Matlab® Simulink models, can also be incorporated into the software. This allows for the creation of a heterogeneous system, but more importantly, enables cooperation between engineers from multiple disciplines and organizations or geographies.

The system design can be quickly turned into a prototype by integrating the modular hardware that can interface with a variety of sensors, transducers, and actuators. Customization and improvements can be made on the fly, and rework of the hardware is kept to a minimum. LabVIEW code can be shared by snippets over the web, and by other mechanisms such as internet forums like NI Developer Zone.

Once the prototype is satisfactory, the same code can be used in the final model, which may require a different set of modular hardware that is optimized for cost or performance. Since little to no change is required in the deployment, the same model can be used for production, which may happen overseas or at any other location. This is essential for project management or product design by distributed organizations over multiple geographic locations.

Finally, front panels of programs that monitor experiments or the state of a system can be shared over the internet through Remote Front Panels in LabVIEW. An example of this will be discussed later in the paper.

Examples in engineering education and international cooperation

Let us examine a few examples, and in them, study the tools that make them possible.

A. Collaborating with -K12 education
B. International industry-university cooperation
C. Industry collaboration for engineering education
D. Remote and Virtual Laboratories

A. Industry-K12 Education: FIRST Lego League (FLL)

Using a common platform, a standard for a fun, challenging international competition is very effective for education [8]. Students build LEGO robots using LabVIEW based NXT software or Robolab to complete tasks on a thematic playing surface. FLL teams, guided by their imaginations and adult coaches, discover exciting career possibilities and through the process, learn to make positive contributions to society.
Figure 2. FIRST LEGO League MINDSTORMS robot

In the FLL program, elementary and middle-school students get to:
・ Design, build and program robots using LEGO® MINDSTORMS technology
・ Apply real-world math and science concepts
・ Research challenges facing today’s scientists
・ Learn critical thinking, team-building and presentation skills
・ Participate in tournaments and celebrations

The final point culminates in an international competition that is not just about winning, but about working together in a concept called “gracious professionalism” that fosters cooperation among children of all nationalities [10].

B. International University Collaboration: E-JUST cooperative program

As a part of Japan International Cooperation Agency’s (JICA) technical cooperation projects, National Instruments has been involved in creating a control design course curriculum for the newly established Egypt-Japan University of Science and Technology. LabVIEW and modular hardware are used to set up a real-time control laboratory for educational and research objectives. The real-time system connects to control objects such as electro-mechanical systems for robotics including DC/AC servo motors, piezo-electric actuators, hydro-electric actuators, etc. The system enables students to obtain dynamic characteristics of control objects such as the time delay from a step response and system identification from stimulus/response signals, design and simulate a controller, and deploy a designed controller in real-time.

Virtual instrumentation was chosen because it allowed for rapid set-up of the laboratory, and its recognition as a platform for effective education in both countries.

C. NI-Industry Collaboration: educational platform development

National Instruments is collaborating with leading international companies and universities to develop a common and most efficient platform for engineering education. Now, the National Instruments Educational Laboratory Virtual Instrumentation Suite (NI ELVIS), featuring an integrated suite of 12 instruments in one compact form factor is ideal for hands-on learning [11]. Modules built on the ELVIS platform help reach more specific disciplines, including:
・ Circuit design & simulation
・ Measurements and instrumentation
・ Control design, simulation, and mechatronics
・ Microcontroller/embedded systems
・ Telecommunications

NI has collaborated internationally with Electronics Workbench (Canada) for circuit design, Vernier (USA) for sensors, Quanser (Canada) for control, Freescale (USA) for embedded systems, EMONA (Australia) for telecommunications application development.
Figure 3. NI ELVIS multidisciplinary teaching platform

**D. Remote and Virtual Laboratories**

Virtual and remote laboratories offer substantial flexible education benefits because students can access them at any time and from any location, features that traditional learning environments cannot easily match [12], [13]. In addition, educators can supplement traditional teaching methodologies with virtual and remote-control laboratory tools. For example, they can be used during a traditional lecture to show students how to apply concepts presented in class to a simulated or remote experimental system. Through the use of LabVIEW Remote Panels, Stanford University’s Cyberlab allows students to log onto a remote optics laboratory to conduct an experiment to measure the physical properties of a laser diode.

Figure 4. Stanford University’s Cyberlab

This approach imbues a classical lecture with an active and flexible learning component, thus strengthening the pedagogical value of the lecture. [12]

**5. Conclusion**

The examples above show the different mechanisms for learning and sharing. They demonstrate the value of
virtual instrumentation as a platform for more effective engineering education and international cooperation. By providing an intuitive interface and an open platform for customization and connectivity, Graphical programming and system design helps engineers across multiple disciplines and geographies work together and grasp concepts more easily than traditional methods. This is essential to attract and develop engineers who are ready for innovation and global collaboration, which are requirements for tomorrow’s engineers.

References

Biography
Ryota Ikeda received a degree in Bachelors of Science in Electrical Engineering from the University of Washington in 1993. He joined National Instruments’ corporate headquarters in Austin, Texas later that year as an Applications Engineer, and one year later, in 1994, transferred to National Instruments Japan, located in Tokyo. After serving as Applications Engineering Manager and Strategic Marketing Manager, he became Managing Director in 1999. He serves on the board of the Japan Society of Applied Science (www.ohyokagaku.org), and chairs the Measurement and Control Systems Design Committee. His interests are in science and engineering education tools for children, including LEGO® Mindstorms and NI LabVIEW Education Edition. An avid baseball player, the author is on the company’s baseball team in which he plays pitcher and infield. He is married and is a father of three boys.