[1]HOW NATIONAL INSTRUMENTS CAN HELP UNIVERSITIES REDUCE DEVELOPMENT TIME AND COSTS WITH COMPUTER-BASED LABORATORY EXPERIMENTS

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Abstract *-- As technology moves on and graduates are expected to leave university with more technical knowledge there is increasing demand on lecturers to train students on the latest technologies. Increasing workload allows less time to incorporate new topics and technologies. In addition lecturers are expected to develop more remote and computer-based learning curriculum. With the increasing time pressures there is a great need for easy to use, flexible tools for developing teaching material. National Instruments has collaborated with a number of universities worldwide to put together a library of computer-based lecture courses and individual experiments that are available for free on National Instruments academic website. National Instruments publishes these resources in order to help universities reduce the time and financial overhead that goes along with the move to computer-based teaching or e-Learning.*

Index Terms – Computer-based laboratories, LabVIEW, DIAdem, Measurement Studio, remote laboratories, virtual instrumentation.

There are a number of ways in which National Instruments can specifically help universities in setting up computer-based laboratories:

- Easy to use intuitive and powerful tools
- Technical and application support
- Courseware, pre-written experiments, examples and ready-to-use code
- A community of users

The move from stand-alone instruments to computer-based and network connected systems bring many important advantages to an instructional laboratory. It also requires a new paradigm or methodology to get the most advantage out of the effort. Some of the advantages are as follows:

- Dramatically more flexibility in the configuration of the laboratory workspace.
- Reduced costs since one data acquisition card can emulate many traditional instruments.
- One tool may be used to demonstrate the theory behind the experiment, allow the student to simulate the theory and then compare it to real world measurements.
- The ability to combine theory with real measurements can dramatically increase the interest and understanding of the student.
- Results are acquired directly into the computer so the student can easily work with a word processor or spreadsheet for preparing their report for submission electronically.
- At the same time that the students are working on their experiments they also gain experience in integrating the measurement system with the network based computer.
- The tools used are the same as those used in many industries.
- The computer-based labs are seen as modern and at the forefront of technology that is generally where the best students want to be.
- Motion, vision, industrial busses and even traditional instruments can be integrated into the system along with many types of electronic measurements.

National Instruments offers a wide range of tools both hardware and software to help realize the benefits mentioned above. LabVIEW is the best known of National Instruments software products, but others such as Measurement Studio for C and Basic programmers, DIAdem for offline data archival and analysis are also available. There are also extensive instruments and interfaces to build a system.

National Instruments' LabVIEW has become the de-facto standard in both academia and industry. There are some fundamental reasons for this and these will be discussed here.

LabVIEW provides an easy to use, quick to learn but very powerful programming environment for lecturers, researchers, engineers, technicians and students. It is also multi-platform and supports the Windows environment as well as Mac, Linux, Sun and Real-Time applications. LabVIEW is specifically designed for Measurement and Automation applications allowing quick application

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development. This means that more time can be spent on learning the content of the course being taught rather than taking up valuable time with a traditional development environment.

There are many specific advantages of LabVIEW above and beyond the intuitive graphical development environment. It is designed to implement simple datalogging application as well as advanced measurement control application at research level. LabVIEW can do this because it is based on a hierarchical and modular structure with the ability to develop reusable blocks of code in the form of sub-routines. The basic files created in LabVIEW are called Virtual Instruments or VIs. These VIs consist of a user interface for the Instrument, known as the front panel, and the block diagram that contains the graphical code. LabVIEW is a compiled programming language with gives it performance equivalent to "C" or Visual Basic.

To reduce development time there are a number of ways of getting started with LabVIEW. These include a library of prewritten, customizable examples, which can often almost immediately provide a simple solution for a wide range of applications. The range of applications that are covered is extensive. The most basic of these examples cover things such as acquiring a signal, plotting it to a graph and saving the data to disk. Another example might be how to use standard sequencers. There are also more complex examples that include frequency analysis, report generation, picture and sound control and a range of I/O interfaces such as data acquisition, vision, motion and industrial busses.

There is also a solution wizard that takes you step by step through the process of defining the required solution in terms of how many channels are to be monitored, whether those channels are analogue input, analogue output, counter/timer or Digital I/O. LabVIEW will then build a solution based on your requirements, which is ready to run or can be modified as the users' skills increase.

The solutions gallery assists you in configuring the hardware and the look-and-feel of the Virtual Instrument (VI) chosen. These Virtual Instruments can be chosen from a selection under the headings of:

- Transducer measurements
- Bench-top instruments
- Voltage and current measurement
- Data logging or control applications

The user can specify the inputs and outputs required and LabVIEW will build the application. The generated code is available for the user to modify when necessary. These solutions can also be thought of as building blocks that can be reused to build larger applications.

When LabVIEW is used it can provide an efficient and intuitive prototyping and experimental tool. In many instances it is used by universities to demonstrate concepts in the classroom. The same tool can be used by the students to simulate problems. Once the theory is understood students can use the same tool in the laboratory and compare theory with real measurements. If the laboratory computer is on the network it is relatively straightforward to give the students the possibility to access the equipment remotely.

The versatility of LabVIEW is shown by its use from secondary school level (via Lego Mindstorm or Robolab) all the way up to large-scale industrial systems. The important thing is that the students learn how to integrate the computer and network with the real world in a consistent environment.

Academic input into the future direction of LabVIEW, and ideas for new features is critical. One specific example is the remote panel feature of LabVIEW6.1. Remote panel features were defined in consultation with academia. They allow for any laboratory set up both directly, in-situ, as well as being able to access all the functionality of the laboratory remotely over a network. This enables schools to share resources with each other for various projects. The schools thus share physical resources and so higher education establishments can split the cost of setting up new laboratories. Students may be physically separated from the equipment by a few metres or may be on different continents. The use of remote laboratories also enables the university to extend, in a controlled manner, hours of access to experimental equipment for the students. An experiment could be set up and made available over the web for students when a traditional laboratory may be closed, Each student may sign up for a pre-determined slot to run the experiment for themselves. Scheduling time slots also means that the higher education establishment can allow more students to work with expensive equipment in controlled environments and the university does not need multiple sets. The code can also be set up to only allow certain computers to have access, whether that is computers logging on from on campus, from a specific range of TCP/IP addresses, or through passwords. Once the programming and configuration is done to set up experiments using LabVIEW there is no extra programming needed to allow your experiment to be accessed over the web. There may of course be the need to rethink the structure of the course.

From the point of view of a lecturer who is starting to consider using computer-based learning in their courses, there are many advantages of using LabVIEW and Virtual Instrumentation. In order to help get started in this area National Instruments has worked with many universities worldwide to put together a series of pre-written courseware.

This courseware is available to download from our website at ni.com and is available for the following subjects:

- Fundamentals of Digital Electronics
- Fundamentals of Analog Electronics
- A Survey of Modern Computer Based Experiments
- Visual Electricity and Magnetism
- Electric Circuits and Machines Laboratory with LabVIEW
- Contemporary Electronics

These are all courses that have been developed and taught by universities worldwide and are copyright free so that any part of the courseware can be used or changed to fit in with individual curricula. Alternatively, the courseware can be used without modification to provide a complete lecture course. All the LabVIEW code that is needed for the course is also provided.

Where the lecturer already has an established course set up or has specific reasons to want to continue with an existing set of lectures, National Instruments offers a set of individual experiments that can be used. There are over 35 of these experiments covering the following fields of study:

- Electrical Engineering
- Computer Science/Engineering
- Mechanical Engineering
- Physics
- Biomedical Engineering
- Chemical Engineering

These cover subjects as diverse as:

- “Voltage-to-frequency Converters”
- “Op-Amp Basics”
- “Magnetic Circuit Fundamentals”
- “Stress and Strain Measurements”

The idea is to have a fully laid out and explained individual laboratory experiment that demonstrates a specific fundamental principle applicable to that subject. Again these are downloadable from our website, and can be used and integrated as part of an existing lecture course.

There are also general customer solutions available through the website that can be used as reference material and which covers a very wide range of subject areas, industry sectors and application areas.

One can access a number of remote experiments through the National Instruments website, one of these is an RC Demo which uses an RC circuit to demonstrate the concepts of charging and discharging time constants. A light bulb is used as the resistor so that the varying current can be visualized as it flows through the circuit.

From the point of view of setting up computer-based laboratories, the concept of Virtual Instrumentation can significantly improve the offerings that universities, colleges and even vocational schools have for existing and potential students and researchers.

With Virtual Instrumentation there is a high degree of flexibility so that there is no need to buy different sets of measurement and automation equipment for different experiments. It would also allow for a single lab to be s
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how the user needs them to be. As long as the requirement falls within the NI2001 frequency-resolution curve in Figure 1 the Virtual Instrument with data acquisition cards can be everything from a spectrometer to a voltmeter or from a strain gauge monitor to an oscilloscope. These can also be easily combined with traditional instrumentation. There are many more advantages to this setup in addition to only

FIGURE.
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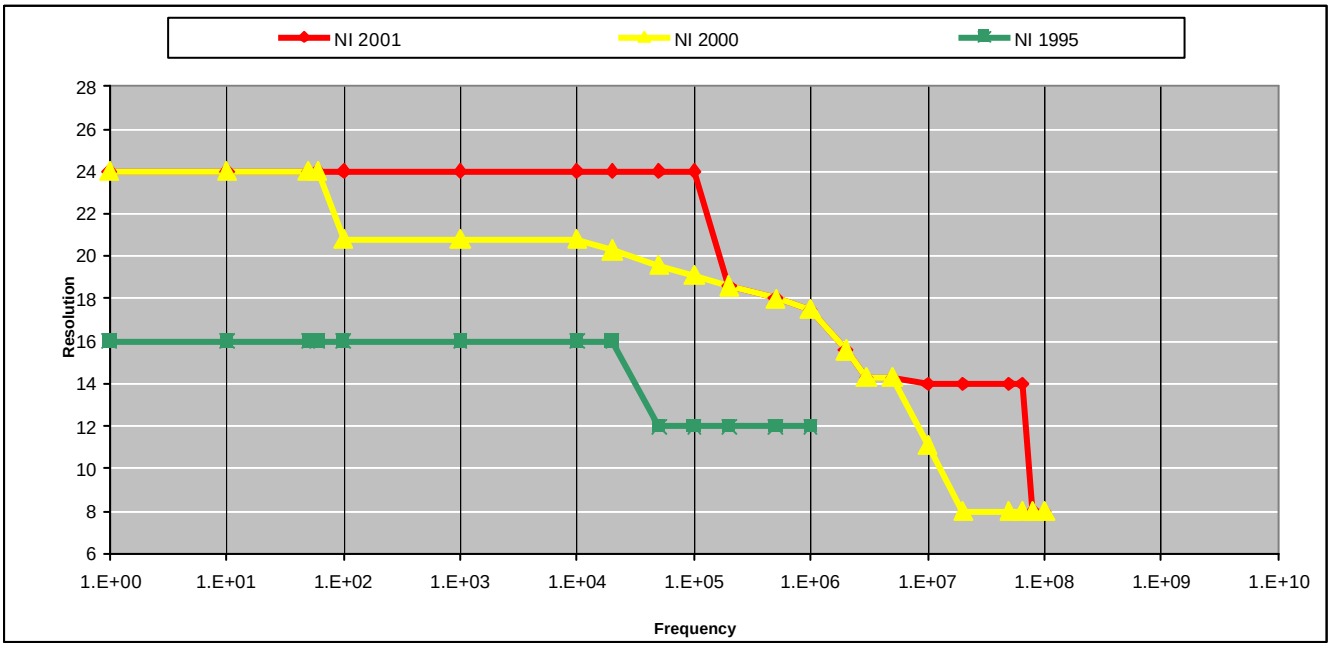
needing one set of equipment in order to be able to run a very wide range of laboratory experiments.

Having the computer take the reading automatically from the Virtual Instrument means that the information is



typically far more accurate in both time and value than having a student read instruments by eye and note the result down in a notebook. The students can concentrate on the results and the interpretation and manipulation of the data rather than the accuracy of their note taking.

Today it is almost always required that students present their results in electronic form. By using Virtual Instrumentation the students gain experience in the use of the computer to get the results and present them in one environment. This promotes a familiarity with using computers to get measurements, undertake experiment and distributing the information over the network. This integration of different systems is becoming a standard way of working in industry with the results ending up in central databases. It also means that all of the results are already in the computer so that the students can focus on the interpretation of the results rather than wasting the time retyping the numbers into the computer.

Virtual Instrumentation is at the forefront of modern technology and as such would show that the higher education establishment is dedicated to modern pedagogical methods. It is known that a vast majority of engineering students already use the computer and Internet extensively. It is therefore an attraction for the best students seeking a career with a future. They want to learn on the most modern and innovative technology this will help to increase the attraction of a universities program.

At a very basic level, having the instrument as part of the computer means that the laboratory is always set up. There is much less wasted time in terms of needing the lecturer or technician to spend time getting out, setting up and clearing away the equipment laboratory to get ready for the next lab.

As all of these tools are widely used worldwide National Instruments can offer significant support and help for technicians and lecturers, from the moment they decide to adopt computer-based instrumentation right through to running lecture courses and experiments. National Instruments will support both them and their students in coursework and project work. The range of support options as follows:

- Web based support – there are significant resources on the website where you can search for answers to common technical support questions.
- Publishing all of the specifications to all our hardware online and in the catalogue – so that it is clear and explicit exactly what our hardware can do
- Field- engineers – a team of degree-qualified engineers are available to visit Higher Education Establishments to provide on site support, advice and consultation in planning new systems.
- Technical Support – telephone or email based support for technicians, post-graduate students and faculty members. The cost of this service is included with the purchase of our products.

We have many software products in addition to LabVIEW. Measurement Studio is a toolkit for those programming in C or Visual Basic. DIAdem is used for offline data manipulation and analysis.

We have been working with academic community for some time and have recognized it as a crucial partner we have a network of users that are often willing to help and advise other academics. There is an academic directory published for those who are starting out on the road of Virtual Instrumentation to find people who are in similar subject areas or who are at the same Higher Education Institution.

Details of all National Instruments products and services as well as information on LabVIEW in teaching and a white paper on distance learning can be found on our website at www.ni.com.