DEVELOPMENT OF INTERACTIVE AND REMOTE LEARNING INSTRUMENTS FOR ENGINEERING EDUCATION

R. Greene, A. Issa, P. Smyth, D. Brabazon, and E. McLoughlin

School of Mechanical and Manufacturing Engineering, Dublin City University.
E-mail: robert.greene2@mail.dcu.ie

ABSTRACT

Many educators have argued for and against the use of remote aids in support of student learning. Some proponents argue that only remote laboratories should be used whereas others argue for the requirement for hands on experience with associated tactical, visual and auditory learning experiences. In this paper we present the methodology for developing a middle ground Virtual Instruments that can be used as a complement learning aid to the hands on laboratory and also if necessary, with added features, can be used as a remote version of the laboratory.

INTRODCUTION

The practical sessions in any engineering course can be used as a supplement to the course material or as a main means for providing a specific component of the course content. Therefore, the need for the student to understand wholly the material covered in the practical session is important. However, often when asked about the laboratory manuals that are provided for the completion of the lab, student's express that this method of teaching could be improved. One way in which this can be achieved is through an interactive approach to the practical sessions, that is to say, more interactive than they currently are. As most practical sessions require or benefit from the use of a computer, an interactive computer program can be used as a guide to the experiment in question. This provides an excellent way of holding the students' attention. Virtual Instruments (VIs) are graphical user interfaces for the laboratory or subject matter that is to be learned.

Another use of these teaching guides is for data acquisition; most laboratory apparatus can be fitted with sensors that can return readings to a computer and present them on the screen. This does away with the tedious or repetitive nature of some practicals, potentially shortening the time in the lab and also keeping the students' interest. It also allows the material to be presented in a clear manner, to ensure that the theory is understood by the student. Given advances in telecommunications and information technology, some university postgraduate programmes are offered by remote access. This means that the student need not attend lab sessions. With this in mind, each VI could also have a remote version that can be downloaded and used from home with sample data from the actual experiment included with these remote versions.

METHODOLOGY

This project is very much a continuation from a previous project with the goal of enhancing the learning environment for students using virtual instruments. These VIs were developed using National Instruments LabVIEW software. This provides an easy-to-use programming environment using block diagrams to construct blocks of code. One advantage that programs produced in LabVIEW have over other programming languages is that LabVIEW comes with drivers for a data acquisition (DAQ) cards. USB DAQ cards and associated DAQ MX drivers were used in this work. This means that a computer fitted with this card can acquire data from the sensory equipment attached to the apparatus. LabVIEW has an intuitive GUI editor which allows the user to create and edit a graphical front-end for the program, which allows an attractive presentation of the subject matter.

There is one virtual instrument for each of the 9 instrumented practical sessions. These are:

1. Experiment to find the shear centre of a C-section beam,
2. Flywheel moment of inertia experiment,
3. Capilliary viscometer experiment,
4. Ultrasonic viscometer experiment,
5. Load cell experiment,
6. Thermocouple experiment,
7. Accelerometer/LVDT experiment,
8. Centrifugal force experiment, and
9. Compound pendulum experiment

Each VI is divided into similar sections. First, an introduction to the background theory is provided. This includes diagrams and formulae specific to the experiment, and an explanation of where these come from. This part contains all the information needed to be able to start the experiment. The next section contains the procedure for the practical session. This is a list of instructions of steps that the student should take in the lab. Usually, this list can be found in the lab manual, but should further explanation be needed, diagrams or animations can be included, which is another advantage of using LabVIEW. The next section is the results section. This part contains any data acquisition subroutines that need to be carried out, and also presents the data in an appropriate form, by means of a graph, chart or table. If the VI is designed as a remote version, then the data acquisition is omitted in favour of generated sample data. The next section is the theoretical calculation. This part of the experiment uses the theory presented in the introduction to calculate various parameters to do with the experiment, and to compare these parameters to those calculated from experimental data. For some of the VIs, some data needs to be passed from the data acquisition section to the theoretical section, and this is accomplished quite easily in LabVIEW. The final section is the report guidelines. This part explains to the student what is expected to be presented in their report for the experiment. Specific instructions to each experiment are included in their respective VI. Also, a general format of an acceptable report is included. This ensures that the student covers all the material required thoroughly.

An addition section is included in some of the VIs, namely the Quiz Section. This part contains several multiple choice questions that the student can answer once the experiment has been carried out. This causes the student to exercise the knowledge that they have just acquired. To show the process of developing the VI in greater detail, the Load Cell experiment will be examined. The front screen of this experiment looks as in Figure 1.

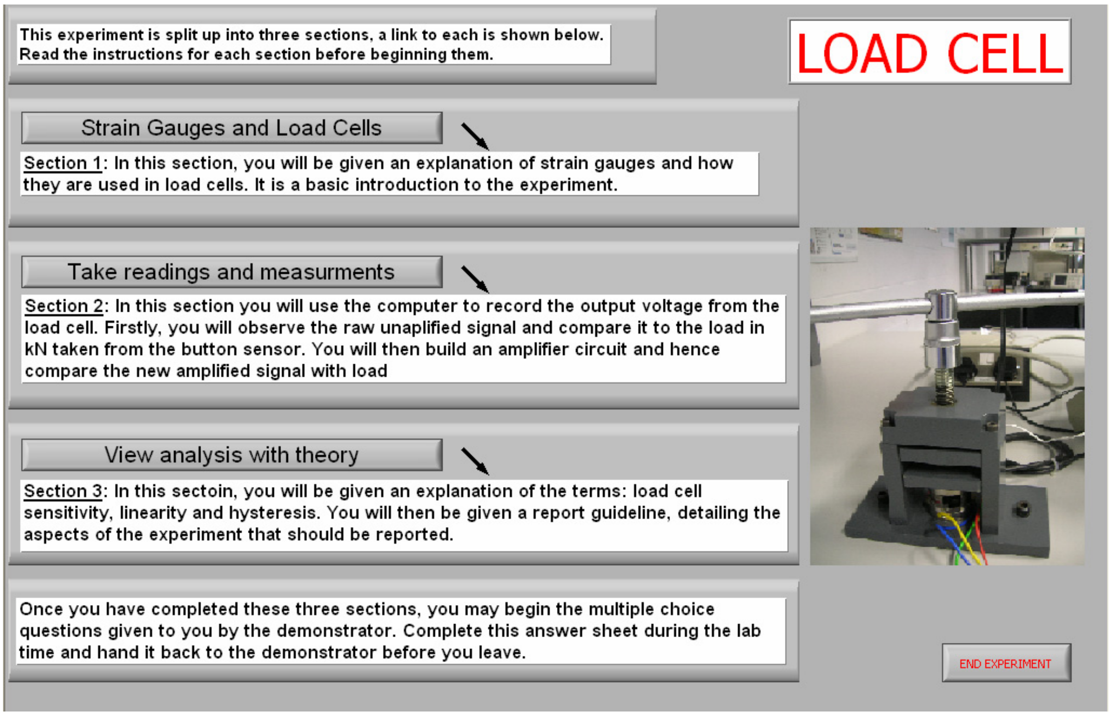

Figure 1: Main menu of Load Cell experiment

An explanation of each section is given under each menu option, and a photo of the apparatus is included. Choosing the first menu option brings up the theory section. This shows the theory behind the Load Cell experiment, which includes various diagrams and animations. A screenshot of one of the screens in this section is shown in Figure 2.

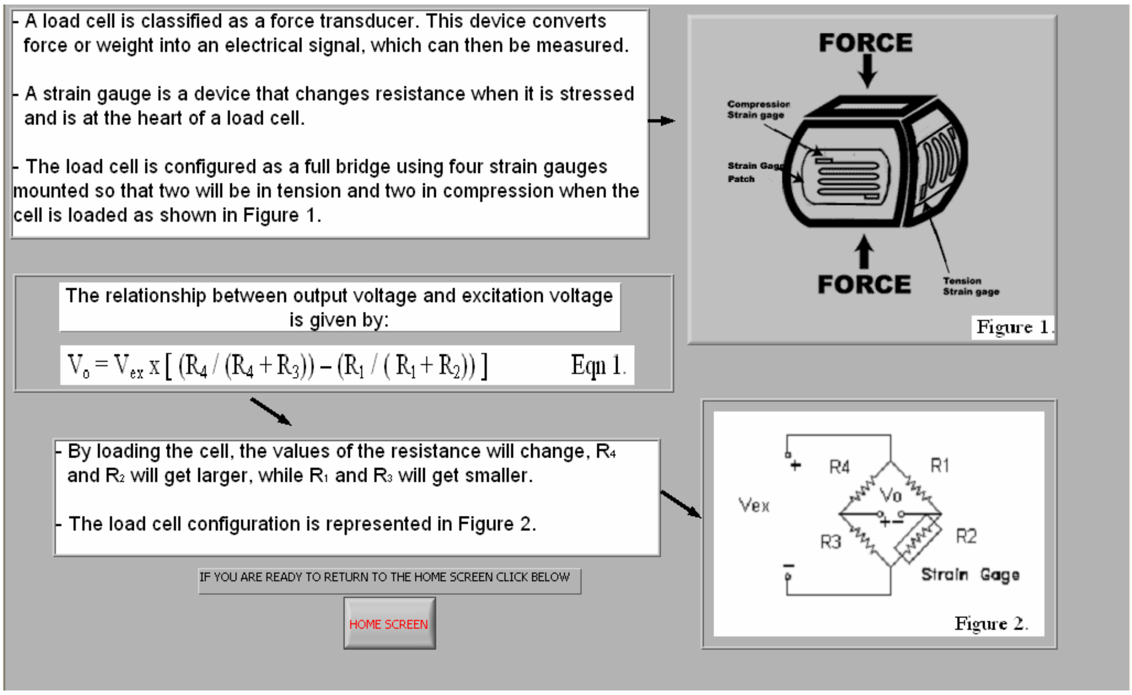

Figure 2: Example of one of the introductory theory screens

From the theory section, the program returns the user to the main menu, from which the second section, the experimental section, can be chosen. The screen that follows states the objective of the experiment, explains how the apparatus should be connected up, how the power supply should energise the load cell and what the student needs to do once this is accomplished. A screenshot from this screen is shown in Figure 3.

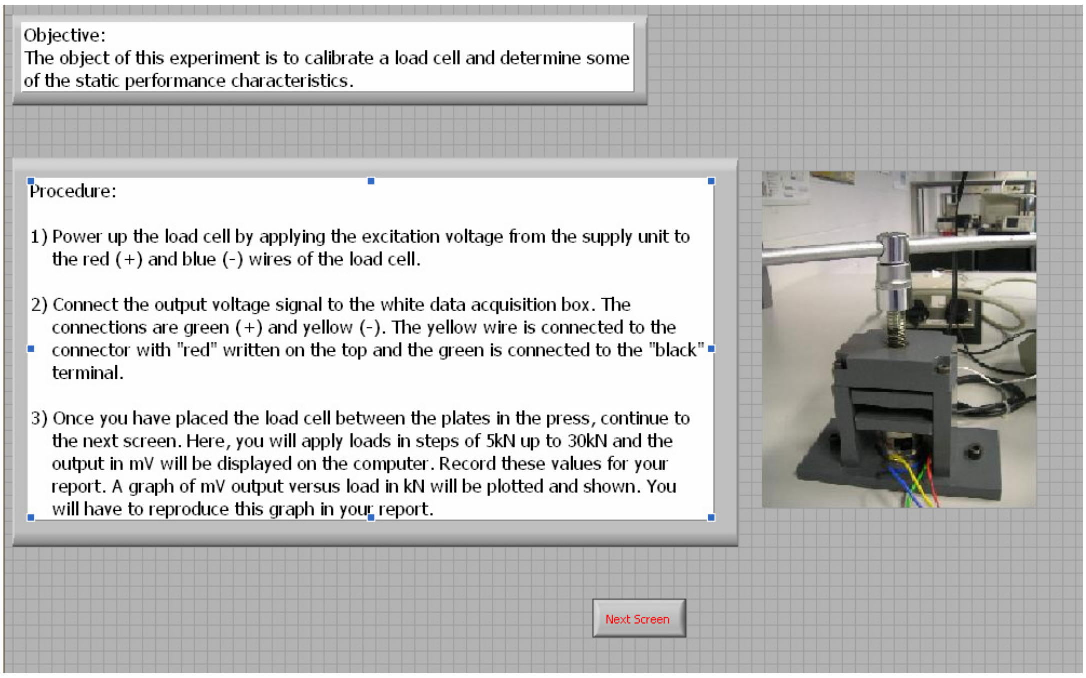

Figure 3: Example of one of the procedure screens with step-by-step instructions

Now that the student has read the procedure, they can move onto the first data-logging section of the experiment. The procedure screen in Figure 3 leads the user directly to the data acquisition section. The screen that appears contains a graph onto which the data can be plotted. It also contains instructions as to how to acquire the data from the apparatus. It indicates that the load cell should have the stated load applied to it, and that the student should then press the “Capture Data Point” button. This stores the load cell reading, and plots it on the graph. This is repeated for each of the required loads. Once all the data points have been stored, the graph can be plotted by pressing the “Generate Graph” button. The data logging section looks as in Figure 4.

The block diagram (program) for the data logging section is quite simple, given LabVIEW’s intuitive visual approach to programming. DAQ Assistant is a module (also called a subVI) in LabVIEW which was in this case used to control the communication between the apparatus and the computer allowing the data to be acquired to the program. Once all the points are plotted and noted down, the student can move on to the next screen. The next screen (not shown) depicts the next part of the experiment giving details how the student should use an operational amplifier (op-amp) to amplify the signal from the load cell, allowing for more accurate load readings. It contains a circuit diagram for the op-amp, and explains how the op-amp amplifies the signal.

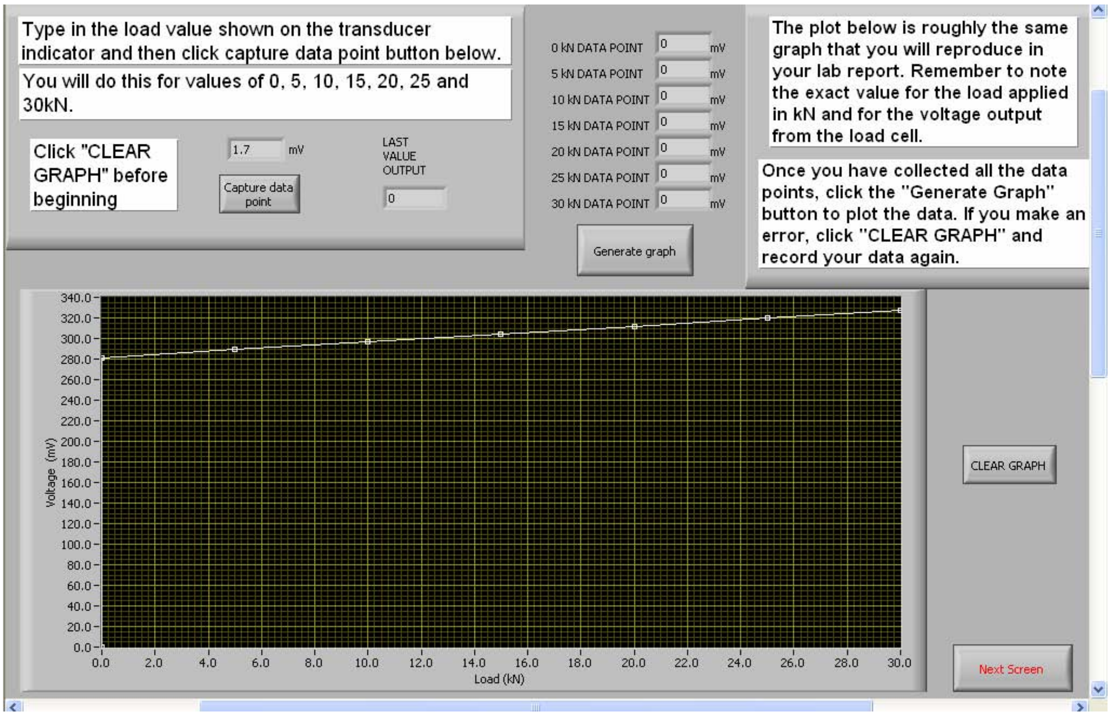

Figure 4: Example of one of the data logging screens

The next screen is another set of procedural instructions, very similar to Figure 3. It explains what the student does when the amplifier is connected. To show that greater control over the load can be given with the amplified signal, the student should take a reading every 2kN up to 30kN load. As the students progress to the next screen they are presented with another data acquisition screen almost identical to Figure 4, except there is space for 16 data readings, for the increased range of loads to be read.

Once the experimental data has been noted down, the student moves onto the theoretical calculations. This section includes more theory, explaining the terms and concepts behind instrument sensitivity and hysteresis. They also contain formulae that will be needed to calculate various parameters that are needed for the lab report. The student can go back through any of the screens again by returning to the main menu and repeating the section of interest.

The next screen gives the student specific guidelines as regards what to write in the lab report. It details parameters that should be calculated and results of the experimental data that should be noted. It also urges the student to comment on the results, stating whether they are expected or unexpected, and also allows the student to identify any possible reason for errors in the experiment. The final screen gives a generic format for the lab report, giving the various sections that should be included, e.g. procedure, results, conclusions. This page is included in all of the VIs. This screen brings you back to the main screen, where the “Stop” button can be pressed to finish the lab. In the remote version of the Load Cell VI, the only difference is with the data logging sections. Instead of using the DAQ Assistant, sample sets of data are included, which can be generated with the “Generate Sample” button. Once the sample data is generated, it can be plotted in the same manner as with the live version of the VI.

DISCUSSION

Many types of models have been used to help guide course designers through the specific steps of analysis, design, development, implementation, and evaluation. Typically these models have been based on the cognitive aspects of what students need to know but have neglected the affective domain of how students can be motivated. The attention, relevance, confidence, and satisfaction (ARCS) model has been more recently applied by a number of workers in an effort to enhance student learning with improved delivery methods. A particularly effective way at engaging and motivating students is the use of directed interactive multimedia delivery of course content [1, 2]. One way of achieving content delivery in conjunction with affirmation of correct progression is with the use of interactive multimedia content interfaces. The inclusion of an interactive media method of delivery provides the potential for pre-planned delivery with tailored timing for provision of information as and when it is needed. Information and content on the softer engineering skills can also be permeated and integrated with this delivery method. In this way, more recent requirements for engineering education including ethics, sustainability, cultural studies, life long learning and social aspects of technology can be incorporated [3].

The development and delivery of course content with Computer Based Learning (CBL) techniques while it has proven to be effective in many instances, the method of content generation and presentation is critical if it is to achieve its goal as an effective learning aid for students [4-7]. Literature shows that students are engaged by and enjoy the variety of learning methods presented by CBL, including in particular notes, self-tests and features to aid visualisation. Timetabled support for their use of CBL where it is complicated is also shown to be a catalyst to their self use of these resources. A desire for very basic content delivery via CBL is not seen as useful and more use of CBL at higher levels including at Masters level is evident [8].

A compelling case can be made for the use of video games to address the current problems with the attractiveness of engineering and retention of students in engineering programmes. Arguments made in support of this include the massive reach of gaming, the ability to incorporate effective learning paradigms, the high level of interactivity, the increased willingness to spend time learning, and the potential to meet and record the required learning outcomes data [9]. Internet based delivery, with its capacity to transmit audio, text, and graphics, presents educators with tremendous opportunities for distance education and independent learning [10].

Many educators argue strongly that the laboratory experience is very beneficial to student learning [11]. Future work would involve incorporating videos of the laboratories within the VIs. Some previous evidence has shown that students taking remote laboratories with videos of the actual experiment perform as well as students taking the laboratory on site. In any case, the provision of the video information would add useful visual and audio information to the remote laboratory [12-14]. Other proponents argue for a combined approach where the student still has to attend the laboratory but is guided through it by a VI or has access to a remote version once they leave the laboratory environment [15]. The VIs developed in the course of this study meet these latter criteria and can be easily repurposed for variations in the experimental apparatus, inclusion of new content, or a re-organisation to the order of delivery for personal preference or to present an improved learning aid.

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