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Teaching a US-based Laboratory Course Overseas*

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The course discussed in this paper, Instrumentation and Data Acquisition, had been taught for two years at Purdue University when the Federal University of Viçosa invited the instructor to teach that course in Brazil. Based on the instructor's experience in teaching the course there, this paper offers suggestions on how to successfully address the problems associated with teaching a hands-on laboratory course away from the home institution where the course was established. The problems included content adaptation, equipment availability, laboratory setup, scheduling, instruction methods, language barrier, funding, and a few other problems. Advantages and compromises associated with the international adaptation of the course are discussed. It is hoped that this paper will help create a model for international teaching collaboration.

Keywords: teaching abroad; globalization; course adaptation; laboratory setup

INTRODUCTION

A PLETHORA OF PUBLICATIONS in the last decade or so have addressed the importance of preparing engineering students for the internationalization of their profession [1]. In most of those publications, international or global education means students studying outside their countries to prepare them for the global business world [2, 3]. Very few articles address the training of engineering educators to prepare them to train engineering students for globalization. Part of this preparation is to study globalization of education from the literature [4, 5, 6, 7, 8]. However, many of the studies show that successful international endeavour requires plenty of face-to-face interactions [9]. Ideally, the educators themselves must gain real teaching experience outside their own country. The first purpose of this paper is to present important issues faced by the faculty when transplanting a course to another university across national boundaries. The second purpose is to present lessons learned by an American faculty member from teaching a laboratory-intensive course outside the US.

THE COURSE AT PURDUE

In the Agricultural and Biological Engineering Department at Purdue University, the Instrumentation and Data Acquisition course was started in the autumn of 1998 as the Department's response to feedback from its alumni in industry. The course learning objectives are:

1. To understand the principles of operation and limitations of common measuring instruments;
2. To model transducers and their operating conditions;
3. To design systems for the acquisition, analysis and communication of data;
4. To gain awareness of economical and societal aspects of instrumentation systems and of presentation of information.

As in most other instrumentation and data acquisition courses, students in the class learn about transducers for pressure, flow, temperature, humidity, force, etc. They also build signal-conditioning circuits such as a strain gauge signal conditioners with a Wheatstone bridge, operational amplifiers and filters. Other experiments include interfacing with global positioning systems (GPS) and various other sensors used in precision agriculture. More information about this course is available in the literature [10]. Details of the course topics, including lecture notes and laboratory handouts are linked to the class home page [11].

At Purdue, this three-credit-hour course is conducted in 15 weeks, two hours of lectures and two hours of laboratory exercises each week. Two of the laboratory sessions are visits to companies to study their data acquisition systems. The class home page is linked to all lecture notes, homework assignments and solutions, practice problems, grades, etc. Students in the course spend about half of the structured class time on hands-on exercises. Every lecture topic is recapitulated with a laboratory exercise in the session immediately after the lectures.

The first few laboratory exercises are building and testing elementary electronic circuits

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commonly required in instrumentation and data acquisition. For these exercises, the course provides common electronic tools and components such as multimeters, oscilloscopes, breadboards, data acquisition PCs and function generators.

Transducers used by the students are those commonly used in industry, including pressure transducers, turbine and positive-displacement flow meters, rotameters, thermocouples, resistance temperature detectors and thermistors. Other instruments in the laboratory include relative humidity transducers, programmable logic controllers (PLC) and differentially corrected global positioning systems (DGPS). Most of the transducers are mounted on a special instrumentation and data acquisition laboratory test stand. The test stand also has machinery hydraulic components such as flow control valves, needle valves, pressure relief valves and a hydraulic accumulator. Currently, the laboratory has three such test stands. The test stand is shown in Fig. 1, and described in detail by Brown and Sumali [12].

For three weeks, students learn graphical programming using LabVIEW™ hands-on course manual [13], the same manual that is used by National Instruments in its training courses. With graphical programming, students create their own 'virtual instruments', such as an oscilloscope with mouse-driven control switches and buttons on a PC screen. The same hardware used to build the oscilloscope can be reprogrammed to function as a spectrum analyser and other instruments.

GROUNDWORK FOR ADOPTING THE COURSE IN BRAZIL

In 2000, ABE 430 Instrumentation and Data Acquisition had been taught for two years at Purdue University, and had made a few impacts in industry and education, including some industrial application of the skills. For example, a graduate from that course was awarded the highest scholarship from the Instrument Society of America (ISA) [14]. One of the criteria for the scholarship was regarded as having the potential to be a significant contributor to instrumentation engineering. In that year, the Federal University of Viçosa (*Universidade Federal de Viçosa*, UFV) invited the instructor to teach the course in Brazil.

Before inviting Professor Sumali to teach the course at UFV, Professor Marçal-de-Queiroz had obtained funding for the laboratory equipment from the federal government of Brazil. Later he visited Purdue and gathered information on Professor Sumali's Instrumentation and Data Acquisition course. He then worked with Professor

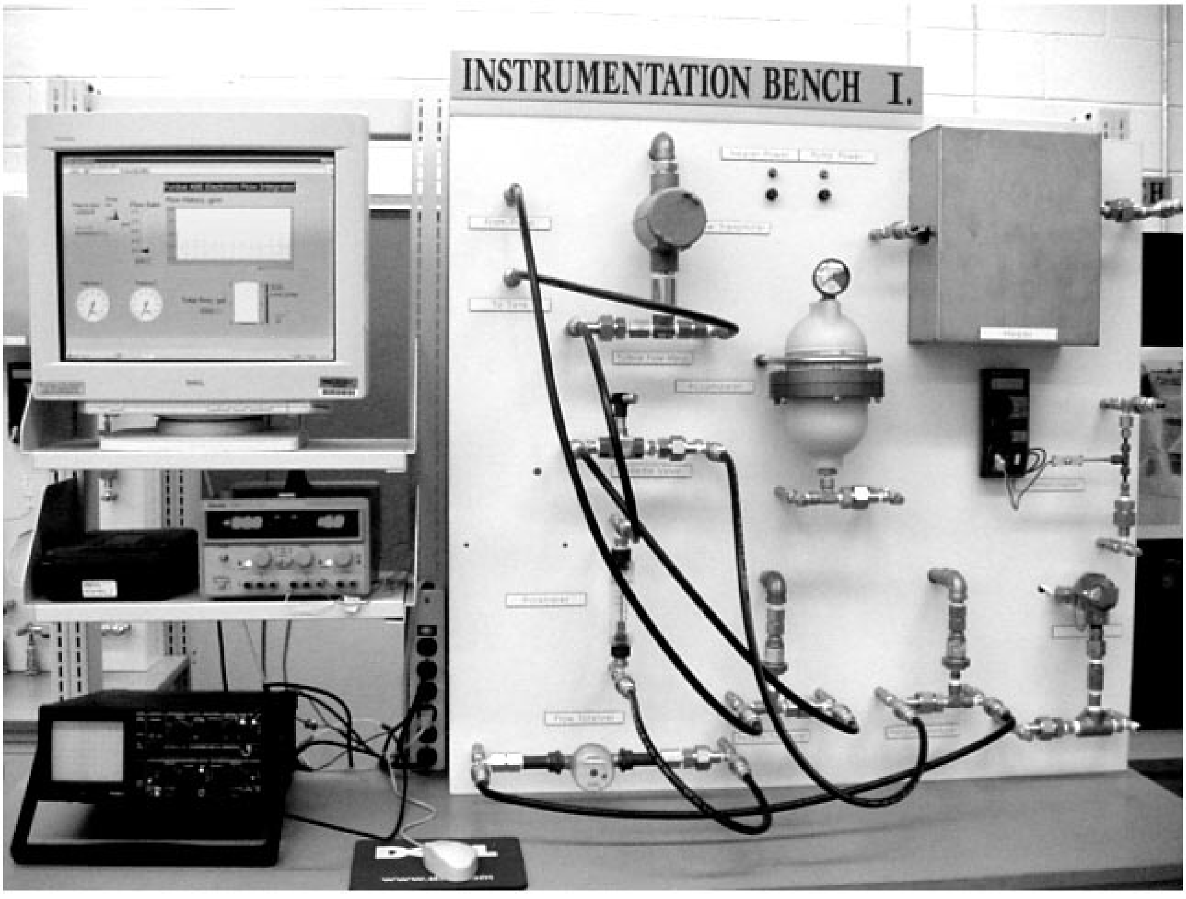

Fig. 1. Purdue's instrumentation and data acquisition laboratory test stand

Sumali to prepare for teaching of the course at UFV. This preparation included:

1. Procuring the textbooks in Portuguese.
2. Producing Portuguese translations of lecture slides, notes, laboratory instructions and other teaching materials.
3. Getting familiar with the course material to become capable of substitute teaching if needed and, more importantly, to be able to teach the course in the future.
4. Performing laboratory exercises.
5. Videotaping several laboratory sessions.

To cover Professor Sumali's travel, accommodation and honorarium for the summer spent in Brazil, Professor Marçal-de-Queiroz obtained funding from the Brazilian National Council for Scientific and Technological Development (CNPq). Subsequently, in consultation with Professor Sumali, Professor Marçal-de-Queiroz prepared the laboratory equipment for the course at UFV.

SCHEDULING

May through July is when most Purdue professors do not have classroom duties. In general, the (northern hemisphere) summer is the best time for North American professors to work outside their institutions. Meanwhile, classes are in session in Brazil. Therefore, Professor Sumali taught the course between May and July 2000.

The instrumentation and data acquisition course was conducted under an intensive schedule. At Purdue, the total contact time of the course is 15 weeks times 4 hours/week = 60 hours. To give the same contact time, the course at UFV was conducted in 20 sessions of three hours. About half of the contact hours were lectures, and the other half, laboratory exercises. This proportion was also maintained at UFV.

Three hours turned out to be a very good length for the laboratory sessions. In the middle of each session, a 15-minute break was taken. However, three-hour chunks of time are not suitable for lectures. Therefore, ten-minute breaks were taken after 50 minutes or a half hour.

EXPERIMENTS AND THEIR ADAPTATION

Most of the lecture topics and materials are readily adaptable to the educational objectives of UFV, which include the creation of expertise in the utilization of modern technology in agriculture. The most important reason for modifying the course details is the different availabilities of equipment. Another reason is the difference in educational objectives between the two departments. The department at UFV is a combination of agricultural engineering and what is known in

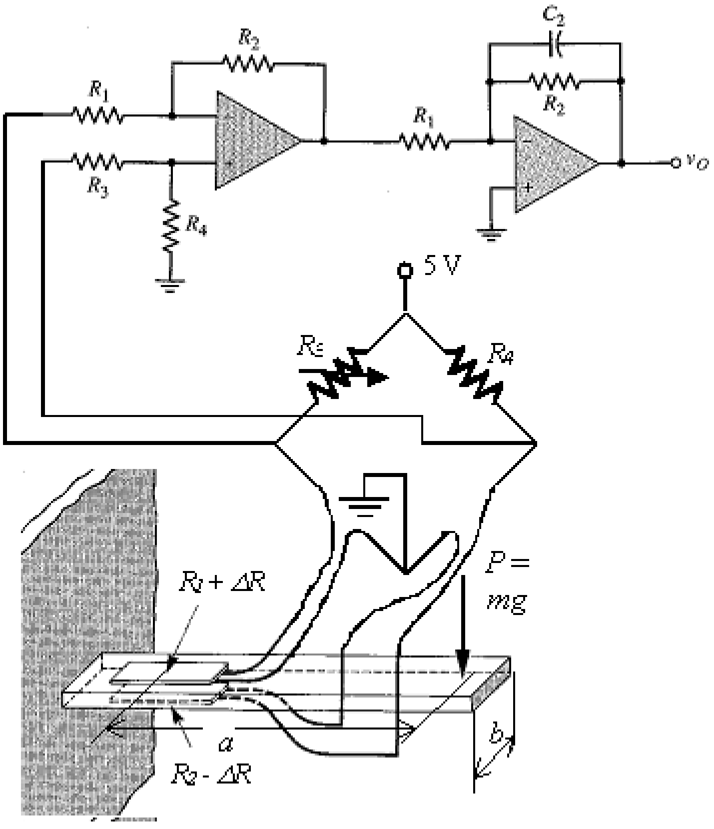

Fig. 2. Load cell transducer experiment at Purdue

the USA as agricultural mechanization (*Mecanização Agrícola* in Portuguese), which requires more practical skills and less mathematical rigour than in the curricula of most US engineering departments. This difference is addressed by reducing the calculus of such topics as first- and second-order dynamics, error propagation, electronic filters, etc, and replacing it with more lab exercises in the installation of strain gauges, data acquisition hardware, radar speed sensor, etc.

An example of the above issue is the adaptation of a strain gauge experiment. At Purdue, this experiment requires students to apply their knowledge of load cells, Wheatstone bridge, operational amplifiers, active filters, calibration and virtual instrumentation, to design and test a load cell and its signal conditioner as shown in Fig. 2.

A virtual instrument on the PC displays the weight on the computer screen. The virtual instrument can also be put into calibration mode, where it obtains the calibration factor from voltage to weight by regression analysis, and removes the tare or other initial offset reading. Given the specifications, students design the beam dimensions and the values of the resistors and capacitor, fabricate the beam in the shop, attach the strain gauges, build the electronic circuit on a breadboard and create the virtual instrument by programming the data acquisition system.

At UFV, students used an off-the-shelf load cell and strain signal conditioner. They spent more time configuring and installing the data acquisition hardware and programming the virtual instrument. The UFV students also played a more active role in preparing the laboratory for the experiment. The virtual instrument written by a UFV student is shown in Fig. 3, with the words translated from Portuguese into English. The virtual instrument can be used to calibrate the load cell using standard weights. The known weight of the standard is typed on the screen. When the Record button is pressed, this weight and the load cell reading are saved in a spreadsheet file. After many different standard weights are used, the stop switch is flipped. Then the virtual instrument reads the spreadsheet file and performs a linear regression analysis to obtain a correction factor for the load cell reading, thus calibrating the measurement system.

Different equipment availability also required adaptation of the course. Having established the course laboratory for two years, Purdue ABE students had been using the test stand shown in Fig. 1. UFV had significant laboratory equipment, but had not built an instrumentation test stand like Purdue's. Experiments that were designed for Purdue's test stands had to be modified. For example, the pressure experiment was adapted to be as shown in Fig. 4.

The purpose of the modified experiment is to calibrate and estimate the precision of a tyre gauge. A precision pressure transducer is used as a

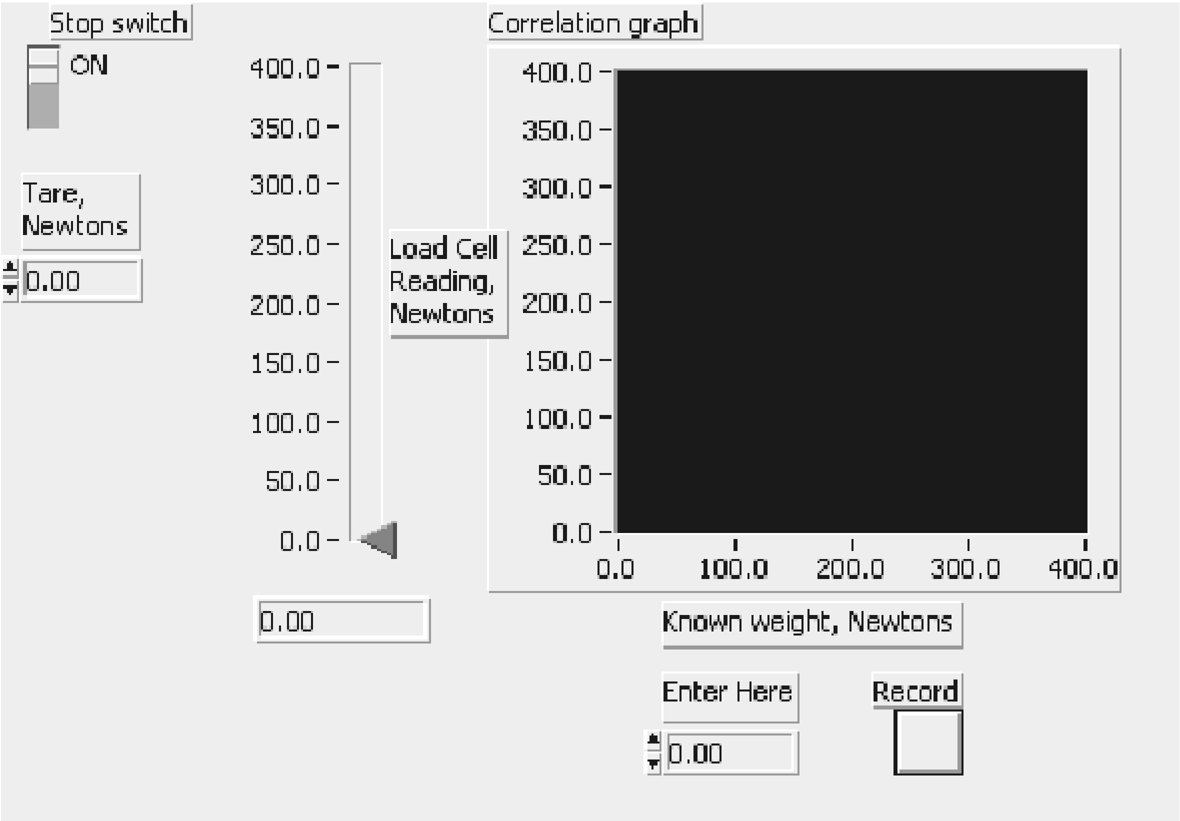

Fig. 3. Load cell calibration experiment at UFV. Virtual instrument

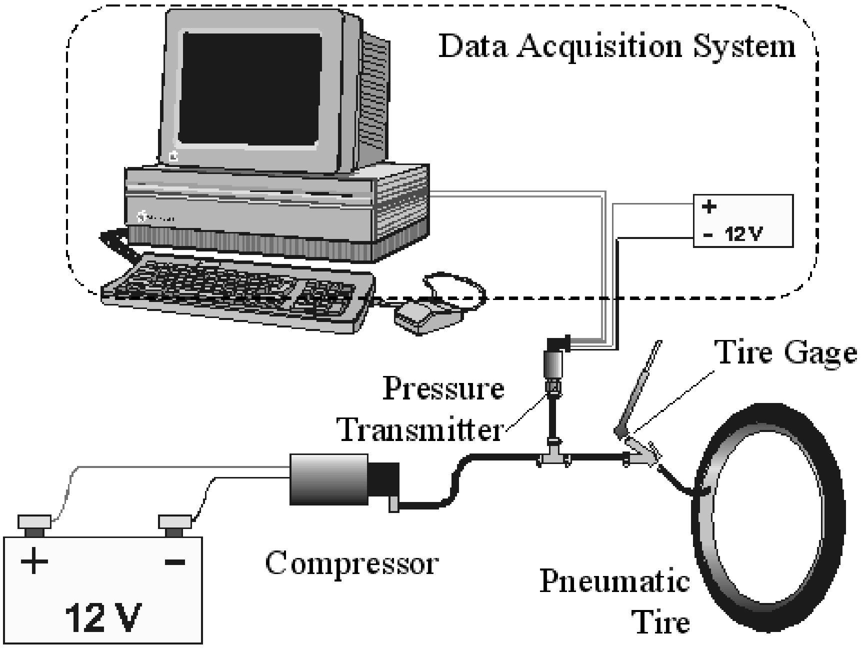

Fig. 4. Tyre gauge calibration experiment at UFV

standard. Air pressure is generated by a compressor and is stored in a large pneumatic tyre. This pressure is measured by a pressure transducer and by the tyre gage to be calibrated. The virtual instrument shown in Fig. 5 acquires the pressures and performs a linear regression analysis to calibrate the tyre gauge and estimate its precision.

Another experiment that was done at UFV but not at Purdue was interfacing a radar sensor for tractor velocity with a data acquisition system. A major part of this exercise is to program the counter and timer of the data acquisition card to count the rate of pulses from the radar sensor. The experiment introduces the concept of gates, clocks and frequency measurement in counters and timers. Other topics on the course taught at UFV, along with descriptions of the laboratory experiments, are listed on the class web page [15].

OVERCOMING LANGUAGE BARRIERS

For an American professor teaching in a country whose language is not English can be a significant problem. In many countries all over the world, most people in higher education speak at least some English. If an American professor is invited to teach at a non-English-speaking institution, it is likely that at least a few people in the host institution speak English and can help the American. It is true in many cases that the American can teach in English and be understood by many of the students in the class. However, experience showed different. The few students who do not speak English become disadvantaged victims. Even students who speak English as a second language may not feel comfortable enough to communicate their questions or remarks to the teachers. If an American speaks no other language than English, she or he may not understand the students. In particular, the professor will likely not understand students' assignment papers well enough to grade them. Effective international education must provide means of overcoming language barriers [16]. The authors suggest a few methods for the classroom.

Speak the language of the students

Ideally, an American teaching abroad should use the language of the host country, at least in combination with English. The following tips may help prepare the teacher: Before going on a foreign assignment, learn as much of the language as possible. Be immersed in the language as much as possible; Socialize with the students and other hosts in their language.

Use an interpreter

In most classrooms, a real-time translation system is not feasible. In that case, translation can be interleaved in the lecture. The translator must be familiar with the lecture topic. A disadvantage of this method is that translation takes valuable time from the lecture and is a wasteful duplication of teaching efforts. Another disadvantage is the risk of information distortion.

Alternatively, the interpreter can work with the teacher before the lecture to produce visual aids in the host language.

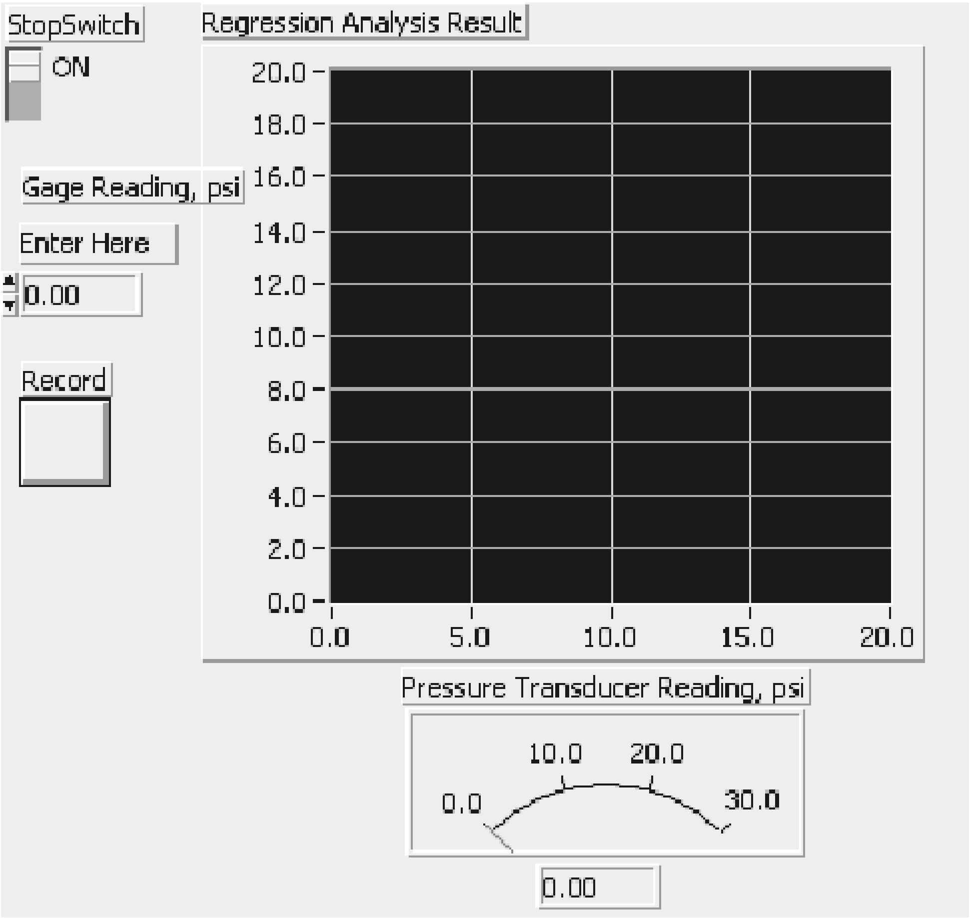

Fig. 5. Virtual instrument panel for tyre gauge calibration experiment

Speak English, but modify your lectures

Here are some suggested 'quick-fixes':

a. Speak slowly and distinctly.
b. Use abundant graphics: pictures, graphs and diagrams. In engineering, students spend a large proportion of the time learning and using equations and graphs. Most of these depend little on language.
c. Use active learning approaches more than lectures. Give students problems, preferably in their language, and ask them to solve the problems in the classroom. At least in engineering, students may learn more when they solve problems than when they listen to lectures.

The teacher who speaks only English will still need an interpreter to translate questions and comments from the students.

On the first days of teaching at UFV, Professor Sumali observed that about a quarter of the students did not understand his English lectures very well. In the first few lectures, he relied heavily on an interpreter (a graduate student of UFV or sometimes Professor Marçal-de-Queiroz). He also applied some of the above methods. In the second week of classes, Professor Sumali started combining the above solutions with a little Portuguese. In the third week of classes, he taught almost entirely in Portuguese. He had spoken Spanish for years before, had learned Portuguese for a few months, and learned Portuguese intensively once he arrived in Brazil.

CONCLUSION

1. The Instrumentation and Data Acquisition laboratory course at Purdue University has served as a model for starting a similar course at the Federal University of Viçosa.
2. Major issues associated with the adoption of the course to a different university have been discussed in this paper.
3. Language barrier is a significant problem when an instructor is to teach in a foreign country. However, several strategies are effective in alleviating or eliminating that problem.

From the author's close interactions with the students in the classroom and in the laboratory, it appeared rather obvious that the students gained the knowledge and capability intended to be gained in the course objectives. Unfortunately, the time frame of the course adaptation project did not allow for quantitative assessment of the outcome of the course at UFV. (The outcomes at Purdue are documented in a related report [17].)

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