Improving the Laboratory Experience with Modern Computer-Based Instrumentation

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Abstract

The extensive use of modern, computer-based instrumentation in industry has created a clear need to provide students with instruction in this technology. This type of instruction is best accomplished by integrating learning experiences in computer-based instrumentation throughout the curriculum. The instrumentation system is first introduced in technical fundamental courses, in technical specialty courses, and finally it is used for design and/or control in senior level courses. By using modern instrumentation in several courses, students' develop confidence and proficiency with this new technology. This paper reports on the method for improving the learning experience in electrical and mechanical laboratories at Lake Superior State University with grant support from the National Science Foundation and the Society of Manufacturing Engineers Education Foundation.

Introduction

Modern instrumentation and control systems are becoming increasingly dependent on computer-based systems. These systems cover the spectrum from data acquisition to design and control as cited by the following references. The use of modern data acquisition systems that use virtual instruments (VIs) is increasing in industry."[1,2] This technology has also influenced the design of modern test equipment with more intelligence "built directly into the machines of today for higher productivity and accuracy."[3] In addition, manufacturing and process control industries are becoming PC converts in instrumentation and control."[4] It is apparent that many areas of industry are changing to modern computer-based instrumentation systems.

Another factor which indicates the importance of graduates having skills in modern instrumentation is company downsizing to a leaner technical staff. According to Steve Lekas, Vice President of New Products at IOTech, companies no longer have fully staffed departments to develop test systems and programs, hence technical employees need to "put their own test system together." [5] All engineering and technology students, therefore, need to have a basic understanding of data acquisition systems so they can correctly and confidently specify and use these systems after graduation.

This paper reports on recent activities in the School of Engineering and Mathematics at Lake Superior State University to strengthen the modern instrumentation skills of engineering and technology students by integrating data acquisition laboratory experiences into several courses. The following sections will outline the general strategy and the corresponding instruction in the updated laboratories.

Laboratory Improvement

Strategy

The strategy to improve students' ability and confidence with modern computer-based instrumentation focused on integrating the use of this equipment into several courses. The overall method or philosophy is to introduce the instrumentation during the early years of the program, reinforce and build proficiency and skills in the middle years, and finally, in the senior year, provide the experience for use of instrumentation in design and analysis of produce design or process control. The target audience included all electrical, mechanical, and manufacturing majors in engineering and technology. The implementation plan, which involves introducing students to the use of this equipment in fundamentals courses and then reinforcing its use in advanced courses and a capstone senior projects course sequence, moves the student from the basic to advanced levels of cognitive learning.

Modern instrumentation equipment was therefore added to several laboratories so that the students would use it in both fundamental and advanced courses. The process of upgrading the instrumentation capability of these laboratories was supported by an Instrumentation and Laboratory Improvement (ILI) grant from the National Science Foundation (NSF) and grants from the Society of Manufacturing Engineers (SME) Education Foundation. The following sections describe the specific laboratory improvements in the electrical and mechanical laboratories.

Early Years

Electrical Laboratory

All electrical, mechanical, and manufacturing students take one or more courses in electrical circuits. The upgrade to the basic electrical laboratory included adding modern pentium computers, data acquisition computer boards, and data acquisition software. In addition to this equipment, which was acquired with the NSF grant, the university also supported the acquisition of modern Hewlett-Packard (HP) digital oscilloscopes and function generators with computer interfacing capability and HP Test Suite software.

Students in the basic circuits courses now have the ability to complete laboratory exercises using computer-based instrumentation. These laboratory exercises can use either the data acquisition computer boards, or use the software and computer capability of the new test instruments.

Middle Years

Electrical Machinery Laboratory

The electrical machinery laboratory is used for laboratory exercises involving ac voltage, power, transformers, and ac/dc machinery. The electrical, mechanical, and manufacturing students complete exercises in this laboratory which previously used mainly analog meters. The upgrade to this laboratory included computers, digital torque and speed test equipment with computer interface capability, and Fluke 41 Power Analyzer meters which also have computer interface capability. The students can now make ac voltage, current, power, and power factor measurements with the meters, and transfer this data to the computer for plotting and analysis. In addition, they can now use the new torque and speed instrumentation when completing electrical machinery exercises.

Materials Testing Laboratory

Several mechanical courses require the use of the materials testing laboratory. The improvement to this laboratory focused on upgrading an existing Tinius-Olsen materials testing machine. The upgrade involved adding a computer and the manufacturer's computer board and software to the machine. When performing various strength of materials tests, the students can now monitor and record the data on the computer with the data acquisition system,[6] and even use the computer to control the entire test.

Dynamics Laboratory

Dynamics is an important engineering fundamentals course. The students' learning of dynamics principles is improved when students complete quantitative dynamics laboratory exercises. The development of a dynamics laboratory included interesting and challenging laboratory exercises that used modern computer-based test equipment. As an example, students used proximity sensors and a digital oscilloscope to measure the time intervals of metallic objects as they traveled down ramps as well as projectile trajectories. This data was obtained with the oscilloscope and transferred to the computer for plotting and analysis. All the experimental results were used to verify analytical results. [7]

Senior Year

Automatic Controls Laboratory

An automatic controls course is required for all electrical, mechanical, and manufacturing students. Laboratory exercises in this course were enhanced when students used modern instrumentation to acquire, plot, and analyze data during various controls exercises. In addition, exercises in the use of data acquisition computer boards were included using data acquisition hardware and software that was acquired with the support of the SME Education Foundation grants.

Heat Transfer Laboratory

The heat transfer course is the third and final course to round of the students' knowledge in the fluid and thermal sciences. The heat transfer laboratory entails an innovative exercise that carries through most of the semester. The students analyze the cooling curve of a steel block in four different ways using analytical strategies. These are: 1) Lumped heat capacity systems, 2) Heisler charts, 3) Finite difference methods using MathCAD, and 4) Finite Element Analysis using ALGOR. Graphs are plotted for each strategy, and compared to results from an actual experiment in which the heated block is allowed to cool, and temperature data is collected using a temperature probe and a data-acquisition system. [8]

Senior Projects

All engineering and engineering technology students complete a year long design project experience. [9] The students work in cross-disciplinary teams to complete actual, solicited projects from industry. Several projects have provided students with the opportunity to use their instrumentation knowledge to develop of sophisticated data acquisition systems for instrumentation and control applications. As an example, this year one team is developing a complex computer-based data acquisiton system that the industrial sponsor will use to collect data while testing automotive components. Another design team is developing a computer-based test instrument to test prototype automotive electrical sub-systems. These design experiences build on the learning experiences in the early and middle years, and allow the students to develop extensive instrumentation systems.

Summary

Students in engineering and technology programs need laboratory experience with modern instrumentation to prepare them to use this equipment in industry. This paper has outlined efforts at Lake Superior State University to build students' competence and confidence with this technology by integrating the use of this equipment throughout the curriculum in both fundamentals and advanced laboratory courses.

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