AN ACTIVE LEARNING MODE FOR LABORATORY EDUCATION

Lang-Wah Lee, Tamer Ceylan
Mechanical and Industrial Engineering
Univ. of Wisconsin-Platteville
Platteville, WI 53818

INTRODUCTION

Thermal Systems Laboratory is a required course in the Mechanical Engineering curriculum at the University of Wisconsin-Platteville. The course is offered to senior students after they have completed four required engineering science courses in thermofluid area. The goals of the course are to: (1) consolidate and integrate knowledge covered in the four courses, i.e. , Thermodynamics, Fluid Dynamics, Applied Thermodynamics, and Heat Transfer; (2) broaden knowledge through applications to solve "real-world" problems; (3) nurture students' creativity and ability in conducting experiments; and (4) develop written and oral communication skills. However, due to the limitations in the traditional instruction method, the potential benefits of the course were not fully realized in the past.

The majority of experiments in the Thermal Systems Laboratory are inherently equipment-intensive and students are usually not familiar with the operation of the equipment. Cost and safety concerns often limit the scope and scale of the experiments. Traditionally, students work with fixed laboratory setups suitable only for routine experiments. They are provided with detailed and rigid experimental procedures to follow. Such a "cookbook" approach creates a passive learning environment in which students' initiative and motivation are suppressed. The learning environment is even more problematic when experiments involving computer data acquisition system are conducted. Quite often, the objectives are obscured by the complicated electronic hardware and computer software. In this case, students consider the entire system as a "black box" and the experiments become rather uninteresting and unstimulating.

The problems mentioned above have prompted the authors to search for new methods to improve the effectiveness of the course. One effective measure is to change the passive learning environment to an active one. Active learning changes the teaching of the course from "teacher-centered" to "student-centered". Such a change not only inspires and motivates students to do a better work in the course, but also sparks increased creativity and curiosity within the students. In addition to these benefits, the students also learn how to conduct engineering experiments in an environment similar to actual engineering practice.

THE DEVELOPMENT OF AN ACTIVE LEARNING ENVIRONMENT

What constitutes an active learning laboratory environment? First, the

laboratory setups should be versatile and flexible to allow students to explore their ideas and thoughts. Second, the method of learning should **rely primarily** on personal **discovery and synthesis. Third, laboratory** activity should emphasize students' **active participation** throughout the entire process. Finally, the laboratory experience should include a **design** component to enhance creative application of knowledge.

The active learning environment is implemented through two phases, namely, inquiry-based learning and project-based learning. These two phases are designed to provide students opportunities for personal discovery and to encourage students in developing their own approach to conduct experiments. A graphical programming software, LabVIEW [1], is used for this purpose.

A Virtual Laboratory for Inquiry-Based Learning

A virtual laboratory component is being developed to implement the inquiry-based learning. Virtual laboratories are computer-simulated laboratories that look, operate, and produce results similar to real ones [2]. In comparison to real laboratory, the virtual laboratory is characterized by its versatility and flexibility because it is software based. These two characteristics make it an ideal tool to significantly improve the undergraduate laboratory education. First, it allows students to explore their ideas and innovations that cannot be achieved in the real laboratory because of concerns for cost and safety. Second, it can be used to provide a pre-laboratory experience prior to the real experiment to deepen students' understanding of and insight into the experiment. Thus the "cookbook" approach in the traditional laboratory education can be avoided. Third, it provides an active and interactive learning environment which would give immediate response to validate correct results. This feature would engage students' attention and active participation. Finally, the approach matches the learning style of most engineering students who learn best from visual, inductive and active learning environment.

Desire Component for Project-Based Learning

The other phase of active learning is the project-based learning. In this phase, the students are required to put together a measurement system and to design their own data-acquisition system. Such activities inspire students to use their imagination and creative thoughts to formulate and implement their design; and to become an active participant instead of a passive follower of laboratory procedures. This deepens their comprehension and elevates their sense of accomplishment and spirit of discovery.

The Tool for Implementation of Active Learning

The tool being used is the LabVIEW software package. It provides a visual programming environment which combines graphical programming with data acquisition, analysis and control. With this software, students can build virtual instruments and systems which are sufficiently realistic with respect to real instruments. To construct a virtual instrument, the students use the built-in icons to assemble an instrument or a **data-**acquisition system with relative ease [3].

EDUCATIONAL MATERIALS FOR ACTIVE LEARNING

The educational materials can be classified into two groups, one for the inquiry-based learning and the other for the project-based learning.

Materials for Inquiry-Based Learning. The center feature of this learning is the development of a virtual laboratory. Experiments in the virtual laboratory can be grouped into the following categories:

1) Electronic sensors and transducers. Sensors/transducers used in the Thermal Systems Laboratory include those for force, torque, displacement, pressure and temperature. Virtual instruments were developed to simulate the static and dynamic characteristics of these sensors/transducers and to demonstrate their performance under various operating conditions.

2) Electronic instruments. Students often have trouble working with electronic instruments, such as oscilloscope, spectrum analyzer, and various types of meters. Virtual instruments allow students to learn how to use these instruments without the worry of damaging them.

3) Actual experimental setups. This type of virtual setups is used to duplicate the actual ones to help students obtain a **pre-laboratory** experience and gain insight into the actual experiment. It would also **allow** students to explore experimental conditions not achievable with the **available laboratory equipment.**

Materials for Project-Based Learning. The central feature of project-based learning is the design activities. The LabVIEW software is a convenient tool in the effort of introducing design elements into laboratory courses. In Thermal Systems Design, such activities can be classified into two categories:

1) Design of virtual instruments.

2) Design of data acquisition systems.

EXAMPLE OF EXPERIMENTS

LabVIEW was adopted as an instructional tool in the Spring semester of 1995. At this initial stage, we have used the software package in the following types of experiments.

1) Virtual laboratory. LabVIEW was used to simulate the following three existing experiments:

a. **Journal** bearing experiment. In the actual experiment, students are to measure the temperature and pressure distribution in the oil film, the frictional torque, and the eccentricity of the shaft with respect to the bearing under various loads and rotational speeds. The eccentricity was measured with two proximity probes whose readings were displayed on an oscilloscope. The virtual instrument is to simulate the measurement of oil film thickness with the proximity probes. It allows the students to visualize the effect of operating condition on the shape of the oil film, the proper way to use the instruments, and the **bearing** performance under

extremely high, load conditions.

b. Water hammer experiment. In comparison to an existing setup in the **Fluid** Mechanics Laboratory, this virtual instrument has the flexibility to vary the diameter and length of the pipe, as well as the closing action of the valve. This allows students to explore conditions not achievable in the actual experiments.

c. Thermal process of emptying a pressurized air tank. The virtual instrument is to simulate the temperature and pressure change during the discharging process.

2) **Design** of **experiments.** This part represents our effort to implement design throughout the entire Mechanical Engineering curriculum. There are two types of design activities.

a. The design of virtual instruments. In this activity, students are to design an instrument to monitor the temperature of an oven. They are provided with a thermocouple, electronic components (such as a breadboard, an **op-amp,** resistors and capacitors) , together with a Pentium computer and the LabVIEW data-acquisition system. The project requires the students to consider signal conditioning, cold junction compensation, the design of wiring diagram for the virtual instrument, and the selection of the output formats.

b. The design of data-acquisition systems. A reciprocating compressor experiment involves with an acquisition system of multi-data inputs, such **astemperature,** pressure, mass flow rate, shaft torque, and the indicated p-V diagram. At present, student's activity is focused on the design of a data-acquisition system to obtain the p-V diagram. The effort requires the combination of signals from a pressure transducer with that from an optical encoder (indicating the volume in the cylinder of the compressor) .

CLOSURE

The introduction of active learning mode has significantly improved the quality in the laboratory education. First, the students are **self-**motivated and enjoy the learning experience. Second, the computer **data-**acquisition system is no longer a **"black box"** tool. Instead, it **helps the** students to attain a better understanding of the experiment. Finally, the active learning mode gives the students more responsibility in conducting experiments and this would prepare them better for future challenges.

REFERENCES

1) G.W. Johnson, LabVIEW Graphical Programming-Practical **Application in** Instrumentation and Control, McGraw-Hill, 1994.

2) P.J. Mosterman et al., Virtual Engineering Laboratories: Design and Experiments, Journal of Engineering Education, pp.279-284, July, 1994.

3) G.B. King et al., Curriculum-wide Systems Programming Environment for Mechanical Engineering Instructional Laboratories, pp. 233-236, 1994 Frontiers in Education Conference.

APPENDIX

A student-designed virtual instrument for recording temperature is included in this section. The instrument was to be interfaced with a T-type thermocouple to monitor the temperature of a hot plate. The design of the system consisted of the following three aspects:

a. Signal conditioning. This includes the design of an **op-amp** to amplify the voltage from the thermocouple and a filter. The wiring of the **op-amp** is shown in **Fig.1.**
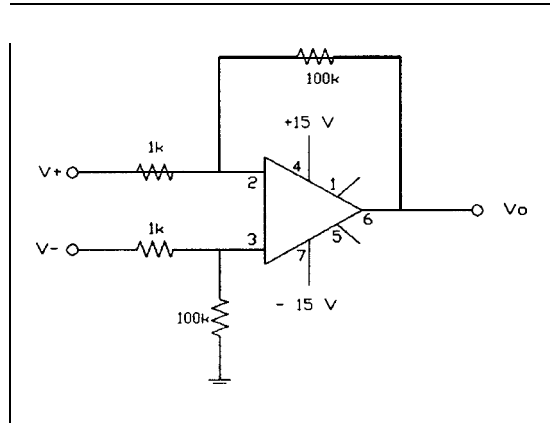

Fig. 1   Differential Operational Amplifier

b. **Front** panel. This is the user **interface** for input and output of signals. LabVIEW allows students to have the **flexibility to install** switches, and means to handle **input** and output data through tables, graphs, or charts as shown in **Fig.2.**
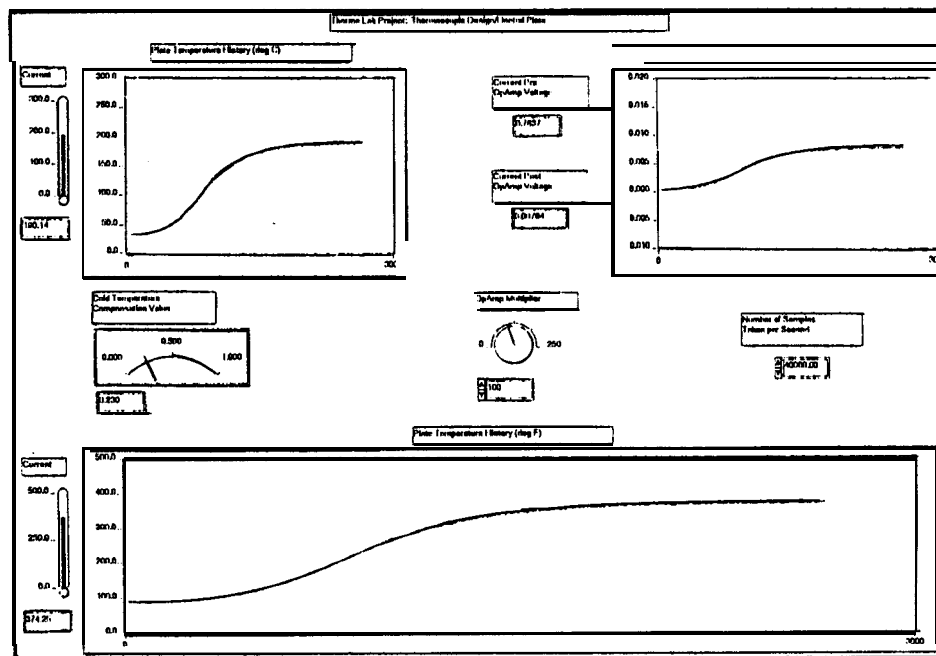

Fig.2 Front Panel for the Temperature Recorder

_c._ Wiring diagram. This is the graphical programming part in which programming is done completely through the use of icons. The process is quite similar to the drawing of a flow chart. The wiring diagram for this virtual instrument is shown-in Fig.3.
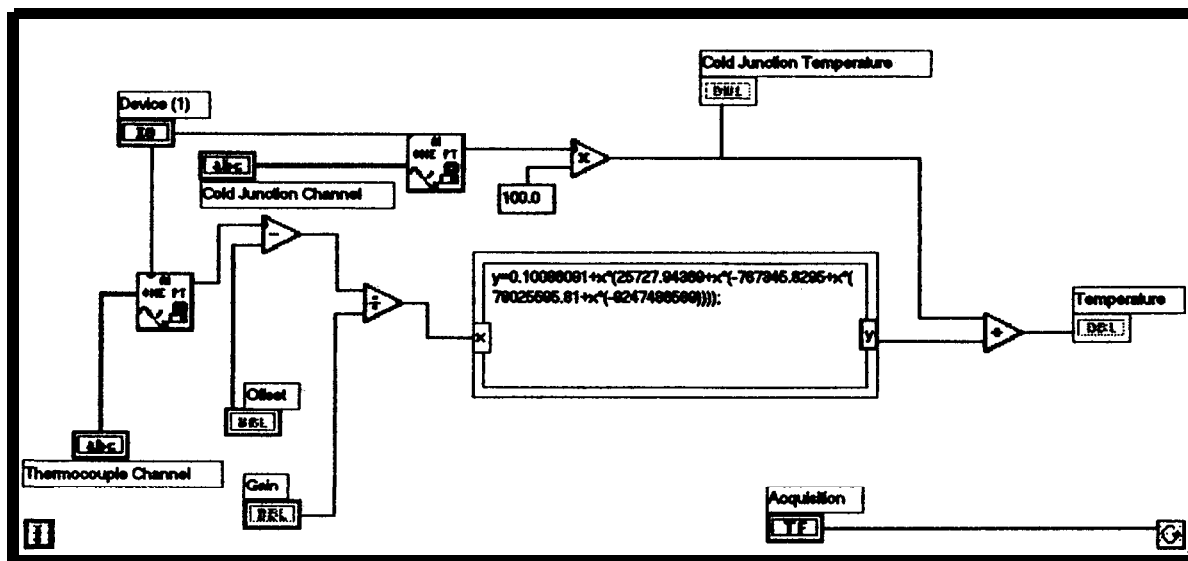

Fig. 3 Wiring Diagram for the Temperature Recorder

BIOGRAPHICAL SKETCHES

LANG WAH LEE
Dr. Lee is a professor of mechanical engineering at the University of Wisconsin-Platteville. He received his M.S. degree (1972) from California Institute of Technology and Ph.D. degree (1975) from the University of Wyoming. Phone: (608) 342-1437, e-mail: lee@uwplatt.edu

TAMER CEYLAN
Dr. Ceylan is a professor of mechanical engineering at the University of Wisconsin-Platteville. He received his M.S. (1976) and Ph.D. (1979) degrees in mechanical engineering from the University of Wisconsin. Address: 1 University Plaza, Platteville, WI 53818. Phone: (608) 342-1367. e-mail: ceylan@uwplatt.edu