

AC 2009-1374: TAKING ACTION: ENHANCING ENGINEERING TECHNOLOGY LABORATORIES WITH LABVIEW-BASED GRAPHICAL DEVELOPMENT TOOLS

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Taking Action: Enhancing Engineering Technology Laboratories with LabVIEW-Based Graphical Development Tools

Abstract

The ever improving technologies raise new challenges for higher education to provide fresh graduates with “ready hands”. To address this concern, four faculty members in the Engineering Technology Department at Prairie View A&M University (PVAMU) proposed to revamp the current Engineering Technology undergraduate lab courses with the powerful industrial popular graphical development environment – LabVIEW, which has successfully been recognized by sponsor NSF with Grant #0714885. LabVIEW can provide an interactive computer-based instrumentation environment which is realized through the integration of flexible software and modular hardware. Its novelty of virtual instruments makes it a dominant tool for R&D, and also an appropriate training facility for higher education.

Engineering Technology is featured with its emphasis on student hands-on skills. This project will cover all the major laboratories in both Electrical Engineering Technology (ELET) and Computer Engineering Technology (CPET) programs, such that students will be consistent in their learning process throughout their undergraduate study. With the recent funding from NSF, we are now in the implementation stage. In the first step, some lab courses have been revamped, and those courses are mainly instructed by the project team. In the next step, the revamping will be extended to the other courses instructed by the other faculties.

In addition, this project has leveraged on several other ongoing grants, including an NSF CCLI grant, an Army research grant, as well as a Title III grant. Through such a strategy, all the students will receive enough training on the latest innovative equipment to reach the goals of inspiring students’ interests in STEM (Science, Technology, Engineering and Mathematics) subjects, and strengthening their marketability upon graduation.

I. Background

Engineering Technology Department aims to educate undergraduates with hands-on proficiency in the latest technology tools. In order to better achieve this goal, educators must keep abreast of the recent technology development and update the curriculum to keep pace with the trend. Meanwhile, how to instruct students to establish a solid ground of laboratories skill is of critical importance.

1. Industry Demand

The development of computer techniques in the past several decades dramatically changed industrial behaviors as well as our daily lives. In recent years, due to the aging workforce^{1,2,3}, and emerging techniques⁴, the industry demands for the entry-level engineers are tremendous.

However, it has been realized by many people including educators that there is a gap between industry needs and current education facilities. Take the example in authors' home Department. Despite many new tools, such as circuit software Multisim, FPGA hardware, DSP board, etc, have been introduced to our students, the lack of a consistent learning environment leading to the discontinuity in the learning, as well as the inefficiency in the instruction. Observing these existing problems, the project team proposed to revamp the current Engineering Technology undergraduate lab courses with LabVIEW. The introduction of virtual instruments and graphical tools will inspire students' interests in STEM (Science, Technology, Engineering and Mathematics) subjects, by getting access to the latest technical innovations, and strengthening their marketability upon graduation.

2. Project Plan

LabVIEW, provided by NI (National Instruments), is a powerful industrial popular graphical development environment developed on a novel concept of virtual instrumentation. Targeted for the educational market, NI provides a design and prototyping platform called ELVIS (Educational Laboratory Virtual Instrumentation Suite). With such a multi-functional platform, as well as many third-party compatible products, the same platform can be used in a wide variety of subjects including circuit, electronics, digital logic, network analysis, digital hardware, robotics, control, microcontroller, mixed-signal, DSP, etc.

Based on the consistent platform of ELVIS and consistent programming environment of LabVIEW, a sequence of lab courses in both Computer Engineering Technology (CPET) and Electrical Engineering Technology (ELET) programs can be developed, from freshmen, sophomore level courses, all the way to junior and senior level courses. Totally thirteen courses will be revamped, including DC Circuit Lab, AC Circuits Lab, Electronics I Lab, Electronics II Lab, Digital Logic Circuits Lab, Network Analysis Lab, Robotics Lab, Digital Hardware Lab, Control System Lab, Microcontroller Lab, and DSP lab.

The two tables below list courses from both ELET and CPET programs which will be involved in a two year revamping period respectively. In addition, two new courses of

Mixed-Signal I and Mixed-Signal II Labs will be added in the list after the approval of the new degree plan.

Type	Course	ELVIS	Multisim	LabVIEW	Others
Required	ELET 1111 DC Circuit Lab	X			
	ELET 1141 AC Circuit Lab	X			
	ELET 2221 Electronics (I) Lab	X	X		
	ELET 2251 Electronics (II) Lab	X	X		
	CPET 2111 Digital Logic Lab	X	X		
	ELET 3241 Network Analysis Lab	X	X	X	
	ELET 3451 Robotics Lab	X		X	Quanser
Elective	ELET 4471 Control Systems Lab	X		X	Quanser

Table 1. List of ELET revamped laboratories

Type	Course	ELVIS	Multisim	LabVIEW	Others
Required	ELET 1111 DC Circuit Lab	X			
	ELET 1141 AC Circuit Lab	X			
	ELET 2221 Electronics (I) Lab	X	X		
	ELET 2251 Electronics (II) Lab	X	X		
	CPET 2111 Digital Logic Lab	X	X		
Elective	CPET 3251 Digital Hardware Design	X	X	X	
	CPET 4391 Programmable Microcontroller Lab	X		X	Freescale
	CPET 4381 DSP Lab	X		X	TI

Table 2. List of CPET revamped laboratories

With such a plan, all the students will receive enough training on a consistent platform with the latest technical innovations. Also, this project will help provide a step stone for the further strengthen and supplementation for the existing facilities.

3. Cross-Talking between Different Projects

Except for the NSF HBCU-UP Grant #0714885 entitled as “Targeted Infusion Project: Engineering Technology Undergraduate Laboratories Enhancement with Graphical Development Tool”, this project has also leveraged on several other ongoing projects, including Army Research Office Grant #W911NF-06-1-0507 entitled “Research and Education in Robust PAM/PWM Controller Design”, NSF CCLI Grant # 0717854 entitled “Collaborative Research: Phase II Development of an Innovative Multi-Functional Smart Vibration Platform”, Department of Education Title III project “Development of Mixed-Signal Systems, DSP Solutions and Advanced Research Laboratories in Engineering

Technology Department". In addition, NI has provided a cost-sharing equipment donation. All these efforts are working together to enhance the educational facilities and environment to better serve our underrepresented minority students.

II. Project Implementation

Starting in 2008 Fall when we received the funds, the team has been working hard to follow the project schedule. The following is the summarization of the achievements.

1. Equipments and Facilities Upgrade

Supported by NSF, 10-seat training stations have been equipped for one lab. Each station has one NI ELVIS with LabVIEW, one Dell desktop computer, one NI Speedy-33 DSP, one Freescale microcontroller board. Meanwhile, another two labs have 12-seat training stations each, to host curriculum development in mixed-signal and DSP solutions. Also, 5-seat training stations equipped with Quanser motor board and rotary inverted pendulum are available in the research center of CECSTR (Center of Excellence for Communication Systems Technology Research), where our students can also get access.

2. Laboratory Course Revamping

For the first semester of implementation, besides the setting up of the equipments, we focused on two undergraduate labs revamping, ELET3451 Robotics Lab and CPET4381 DSP Lab. Also, one group of senior project students from both ELET and CPET had utilized those revamped facilities to finish their project.

a. ELET3451 Robotics Lab

In the fall 2008 semester, 15 students enrolled in ELET 3453 Robotics lecture course and its co-requisite of ELET 3451 Robotics Lab. Since it was the first time for those students to work with LabVIEW, two graduate students in Electrical Engineering Dept, who are now being supported by the Army grant, helped instructor to organize the lab course.

In Figure 1, graduate student first introduced some basic knowledge of LabVIEW environment, virtual instrument, and the Quanser motor board configuration. Then those students can conduct experiment on the NI-Quanser motor board to test the motor, construct motor modeling, and then design the speed controller, which is demonstrated in Figure 2. The motor board, provided by Quanser, is not only compatible with NI ELVIS and LabVIEW, but also is bundled with a series of undergraduate labs that students can easily get started, even for those without much experience with LabVIEW. These plug-and-play products not only significantly lessen the burden for the instructor, but also create a friendly and consistent environment for the student learning. Figure 3 is the vendor provided lab assignment, which has been proved to be very effective. This conclusion is based on the student feedback mentioned later in Section III.



Fig. 1. Graduate student is introducing LabView for undergraduates



Fig. 2. Undergraduate students make laboratory assignment with NI-Quanser ELVIS motor board in ELET 3451 Robotics Lab

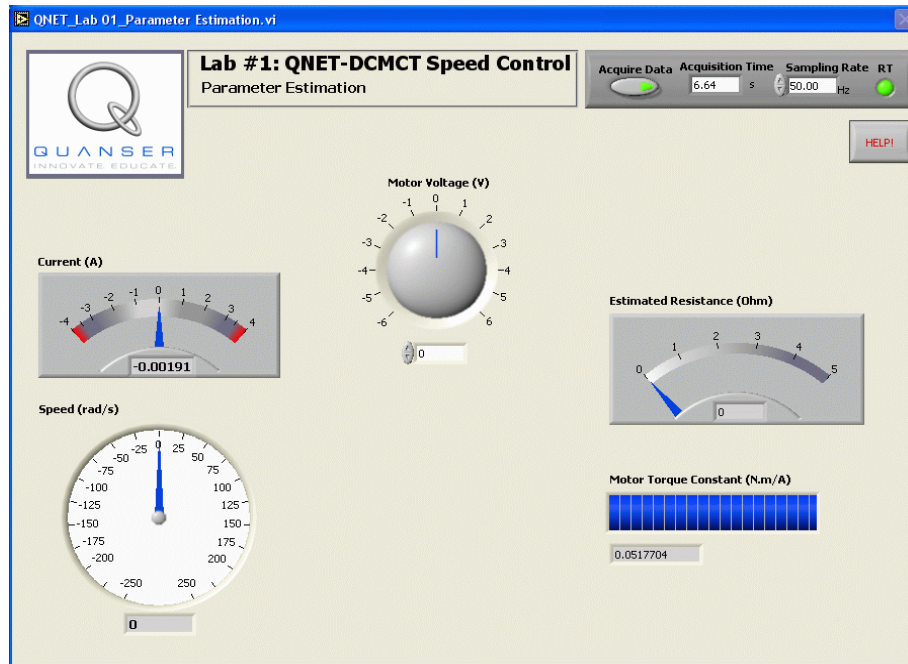


Fig. 3. Lab assignment provided by Quanser

The laboratory revamping plan is further strengthened with inter-institutional collaboration. Support by NSF CCLI Grant #0717854, our students can now get access to the smart vibration platform located at University of Houston, as shown in the Figure 4. The remote control is realized through LabVIEW, and this demo achieved very positive response among the students.



Fig. 4. LabVIEW-based online remote control for the smart vibration platform located at University of Houston

b. CPET4381 DSP Lab

In this lab, currently the textbook of “Digital Signal Processing System Design – LabVIEW-Based Hybrid Programming”⁵ by Dr. Kehtarnavaz is adopted. LabVIEW provides graphical environment which helps students understand abstract digital signal processing concepts. In the LabVIEW environment, Block Diagram clearly illustrates the schematic design of the DSP system, and in Front Panel students can easily manipulate the input data to observe the changes. During the first semester’s implementation, students like these types of experiments which give them a visual understanding of the signals. Figs. 5A and 5B refer to Block Diagram and Front Panel respectively, in which the procedure of signal generation and processing are clearly demonstrated.

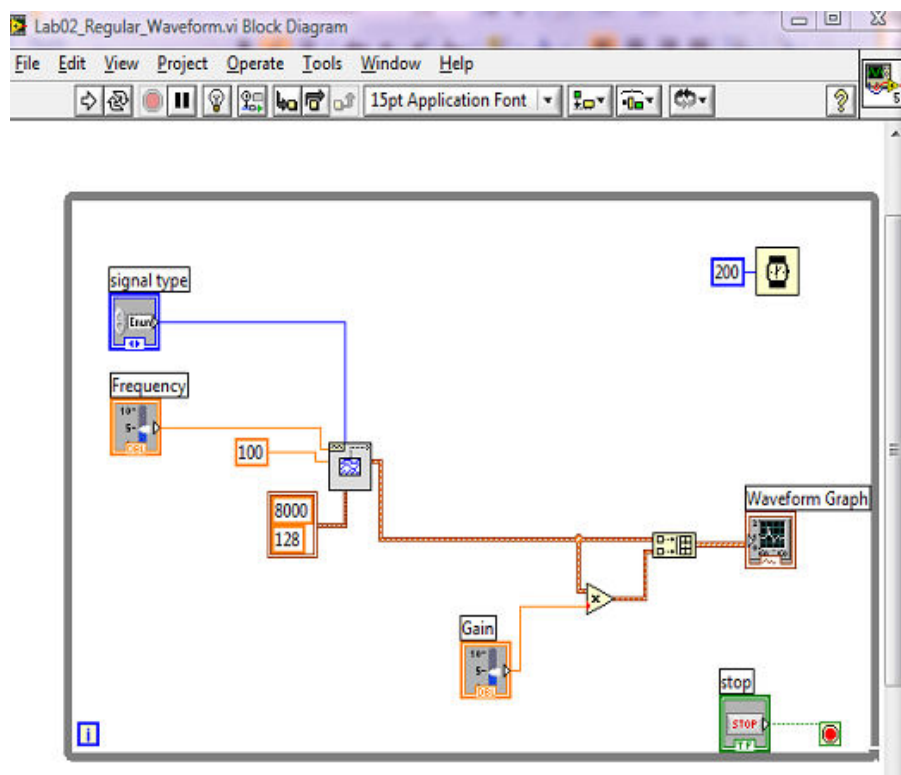


Fig. 5A Block Diagram of one DSP Lab

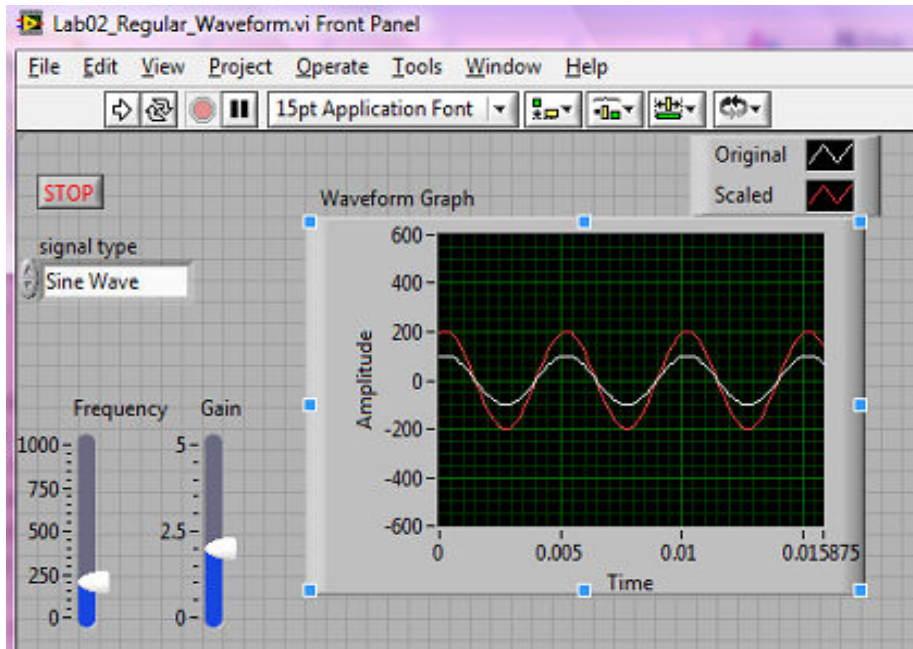


Fig. 5B Front Panel of one DSP Lab

c. CPET4082/4092 Senior Project I & II

Even before the NSF project officially started, one group of senior project students has been utilizing the LabVIEW in their senior design. This pilot project provided good preparation for the ongoing regular lab course revamping. In 2008 Fall, the student team, composed of three minority female students including Allyson Washington (CPET&ELET double major), Camillia Whiteside (CPET), and Ashley Jones (CPET), made a presentation at Argonne National Lab Research Symposium shown in Figure 6, entitled “Gas Gauge Measurement Error Compensation with LabVIEW”.

Also, in the 2008-2009 academic year, another group is now using LabVIEW to realize the online remote control for the video camera.



Fig. 6. Student Presentation in Argonne National Lab Research Symposium, Nov 6-7, 2008.

III. Student Survey

In the revamped lab courses, student survey was conducted to collect their feedback and comments. In ELET 3453 Robotics / ELET Robotics Lab regarding the NI-Quanser motor board utilization, the questions are designed as the following table 3 and results are shown in Figure 7. In CPET 4383 DSP / CPET 4381 DSP Lab regarding LabVIEW utilization, the questions are the same as of table 3, but the results are shown in Figure 8.

A	I found LabVIEW easy to use
B	I did find ELVIS to be a friendly platform
C	Virtual Instrument did help me understand the concepts in lecture
D	Virtual Instrument enhanced my comprehensive skills in use of hardware and software
E	The use of Virtual Instrument increased my excitement about engineering Technology
F	I will be able to apply LabVIEW in my senior project
G	I do believe I will be able to use ELVIS in my senior project
H	I believe my use of LabVIEW in this revamped laboratory will make me better prepared for future employment
I	I believe my use of ELVIS in this revamped laboratory will make me better prepared for the potential graduate school study
J	I am inspired by this revamped lab

Table 3. Survey questions

ELET 3453 Robotics

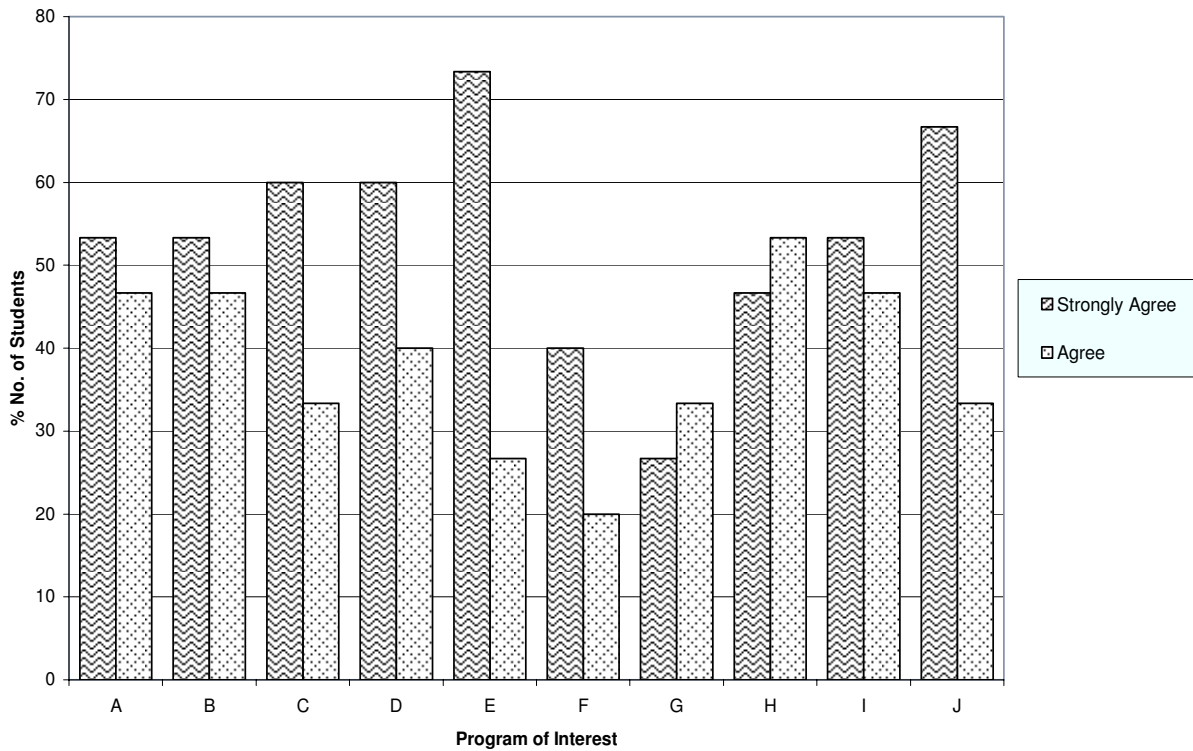


Fig. 7. Survey Results from ELET3453/ELET 3451 regarding NI-Quanser motor board

There are five options for each question, including (i) Strongly Agree; (ii) Agree; (iii) Somewhat Agree; (iv) Disagree; and (v) N/A.

Fig. 7 demonstrates the student responses for the revamped lab of ELET 3453/3451 regarding NI-Quanser motor board. Obviously, the feedbacks are generally quite positive. For example, 72% students selected (i) Strongly Agree, and 28% selected (ii) Agree for the question (E) The use of Virtual Instrument increased my excitement about engineering Technology.

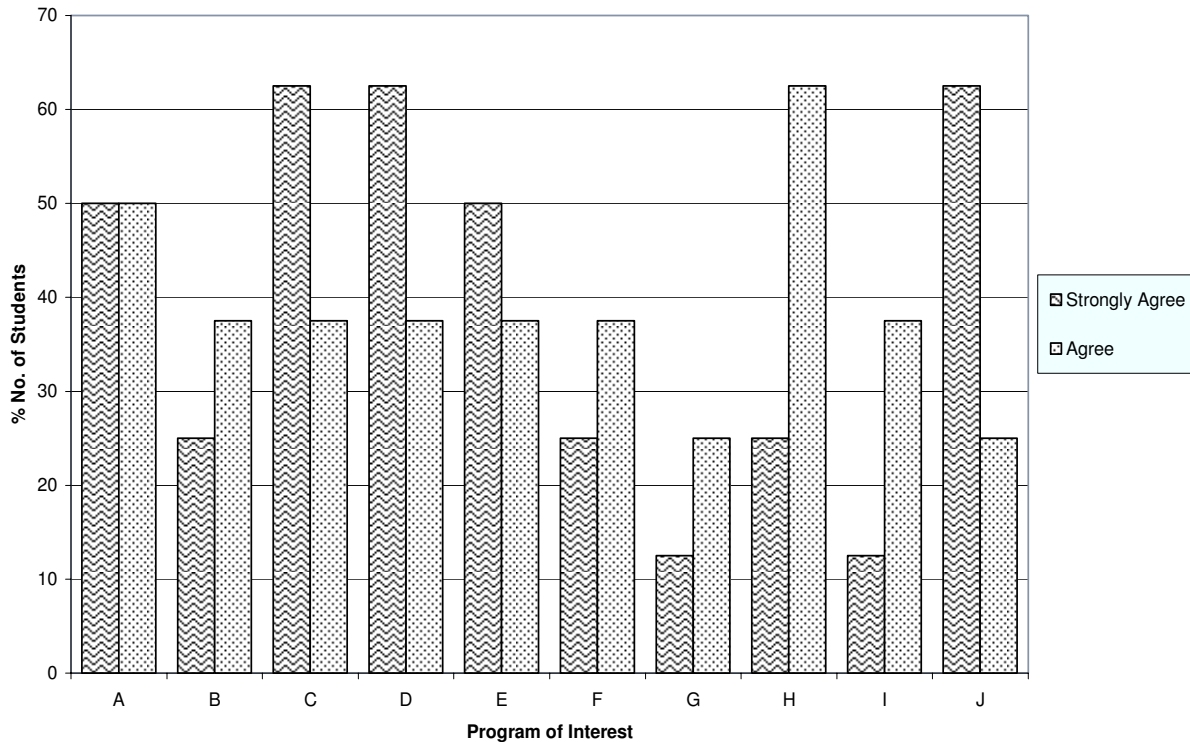


Fig. 8. Survey Results from CPET4381

In ELET 3453 Robotics / ELET Robotics Lab regarding the online remote control for Smart Vibration Platform at University of Houston, questions are designed as the following Table 4 and results are shown in Figure 9.

A	Structure Vibration Control is an interesting topic
B	I feel online remote control via LabVIEW is very interesting
C	I hope our lab at Prairie View will also have the seminar online remote function available.
D	This demo did help me understand the concepts in lecture regarding feedback
E	The use of Virtual Instrument increased my excitement about Engineering Technology
F	I may consider LabVIEW, control system, or related topics in my senior design
G	The experiment demonstrates the concept of smart Materials (shape memory alloy, MR fluid) well
H	I believe my knowledge of LabVIEW in this remote access laboratory will make me better prepared for future employment
I	I believe my involvement in the latest facility will make me better prepared for the potential graduate school study
J	I am inspired by this demo

Table 4. Survey questions

ELET 3451 Robotics Lab

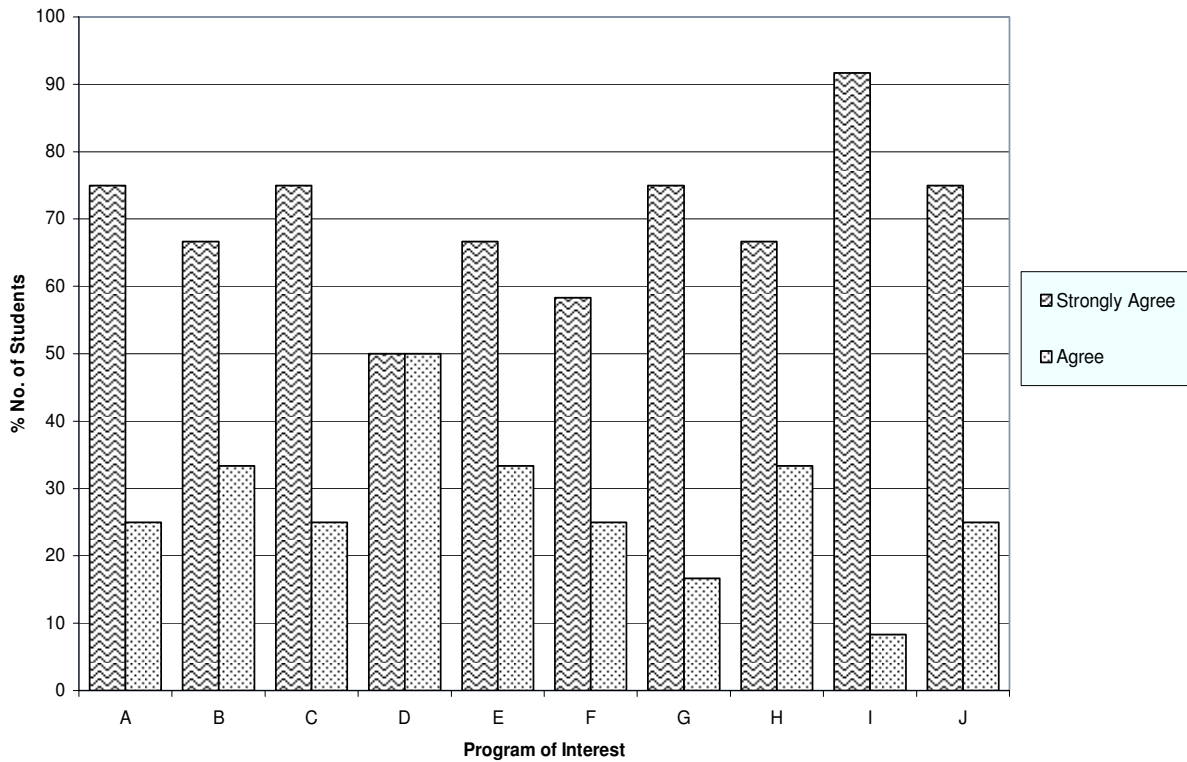


Fig.9 Survey Results from ELET3453/3451 regarding online remote control for the Smart Vibration Platform

The preliminary analysis for the above statistic data is very satisfied. The project team is now working with some professional evaluator to further investigate the survey design, to achieve a more convincing conclusion on the project effectiveness.

IV. Future Work

Except for the efforts by the project team, to establish a series of pipelined lab courses on the consistent platform, the next step is to involve more faculties in the revamping plan. In 2009 summer, a faculty workshop will be held to help the other faculties to get prepared for the new technologies, such that the latest facilities can be further utilized in the lower level courses including DC circuit, AC circuit, Electronics I, Electronics II, Digital Logic, etc.

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