Innovative Improvements to Engineering Technology Laboratory Education to Engage, Retain and Challenge Students of the 21st Century

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Abstract

The paper presents a departmental sponsored project, CLABS (reads as C-LABS), in the Computer Engineering Technology program at the University of Houston. The initial efforts are presented during start of the project in summer 2004.

The paper presents the results of formative assessment of the engineering technology laboratories: a national survey to learn more about what other schools are doing in their laboratories, the development and later analysis of different survey instruments for the full-time and part-time faculty, board of industrial advisors, teaching assistants, students, alumni and simulation software vendors. The initial tasks also included visits to the local junior colleges and community colleges where the program receives majority of its transfer students and meeting and interviewing their faculty. For better dissemination of the experiences, a CLABS web site has been developed.

The major thrust behind the philosophy of the CLABS project is determined by the help of the extensive research through surveying and interaction with other colleges: to move away from the cookbook style laboratory manuals. The purpose is to achieve fun, creative, challenging and more importantly, applications-oriented laboratories that lead the students to a project as a final product of their learning experience.

The paper will discuss survey results, administrative experiences and challenges in deployment. It will attempt to draw some meaningful conclusions so that it can pave the way for future laboratory development in similar programs.

Introduction

The most desired educational outcome of an engineering technology department is the creation of **skillful technologists who are able to approach the design and application of both**

hardware and software with aptitude and creativity. Recent studies such as [1,2] show that there is a skills gap between traditional training and the skills actually needed in today's job markets: cognitive flexibility, creativity, knowledge transfer, and adaptability. Therefore, being able to solve new problems based on the knowledge acquired has become a desired outcome of higher-education institutes. The study of science, technology, engineering, and mathematics (STEM fields) is a means to introduce these skills required in today's society. However, STEM will reach this goal only when the education is engaging, interactive and delivers a set of leadership, teamwork, problem solving, analytical thinking, and communication skills. In order to close this educational gap, the long-term goal is to create a progressively more engaging laboratory experience with problem solving emphasis and various skill and knowledge acquisition.

At the University of Houston's College of Technology (COT), the Computer Engineering Technology (CETE) Program is seeking to teach students to acquire excellence in laboratory skills by revamping the instructional materials in all core laboratories. The objectives are: **(i)** active and hands-on student engagement to develop excellent problem solving and troubleshooting skills; **(ii)** provide opportunities for the students to develop teamwork skills; and **(iii)** encourage lifelong curiosity towards science and technology by establishing a just-in-time learning environment [3] with project-based materials, instruction, and research emphasis.

This paper highlights the major findings and recommendations of the CLABS Project, sponsored by the Engineering Technology (ET) Department and the Dean's office of the College of Technology at the University of Houston.

The paper begins with the rationale, CLABS educational objectives, followed by summary of the surveys, summary of simulation software research, introduction to the web site for CETE laboratories, and ends with a set of recommendations.

The CLABS Project team developed a framework for the operation of the CLABS. This framework was presented to the ET faculty in fall 2004. With unanimous approval of the faculties, the project then moved into its implementation phase.

Rationale: The Need at the Computer Engineering Technology Laboratories

The CLABS initiative is outgrowth of student and faculty opinions: in the present form, majority of students and faculty do not perceive laboratories as "preparing students to evaluate technological issues from a scientific perspective" [4]. A team of CETE faculty and technical staff was formed in summer 2004 to design learning-centered instruction tools which would increase student engagement and address the unique requirements of stand-alone laboratory instruction. Initially, CLABS team collected information on opinions, observations, and expectations through surveys (full-time faculty, part-time faculty, students, lab assistants, industrial board of advisors,

nationwide technology listserv, and electrical circuit simulation software companies) [4,5] as well as site visits to several local institutions. Table 1 summarized the identified needs:

A just-in-time learning experience [6] can address many of the needs in Table 1: start from the need to build a product, build the foundational knowledge, acquire necessary skills to test and verify before implementation, and deliver the product. This fast-paced change in technology and the diversified workforce demand the learning experience to be comprehensive enough on the fundamentals of concepts towards future advances. In addition, the learning styles of diverse body of students should be adequately covered towards enhancement of innovation and reativity [7, 8].

Table 1. Identified needs at the Computer Engineering Technology Program laboratories.

more fun while learning	• complementary software and hardware emphasis
• more creativity	• less repetition of covered concepts
• no cookbook style labs	• better instructor and lab assistant coordination
• synchronization with lecture	• customized manuals
• less crowded labs	• more qualified instructors
• more open lab times	• better oral and written communication skills
• encourage teamwork spirit within a project	• experience extending from ordering the parts to putting it altogether for a final product in a project
• better assessment of levels of transfer students	• increase outreach to transfer institutions to share resources for collective improvement

CLABS Educational Objectives

The objective of the CLABS initiative is to train students towards graduating with a skill set that allows them to anticipate and respond to the changes in fast-paced technological advancements: hardware/software system integration and troubleshooting, communication, and a state-of-the-art technical hands-on experimentation. The expectations outlined above are realizable with a combination of different practices in a laboratory experience. For instance, the nationwide technology listserv surveys indicated practices with pre-lab activities, extensive skill development activities during labs, post-lab reporting, pre- and post-lab teamwork, and components-to-product project-based approaches. However, these practices were implemented in isolated instances [4]. When these practices are combined, the technology graduates will be equipped with both soft and hard skills. In this respect, CLABS team included pre-laboratory simulations and post-laboratory reports, applications of each concept, faculty coordination of lecture and laboratory, and inclusion of advanced assessment tools for continuous improvement.

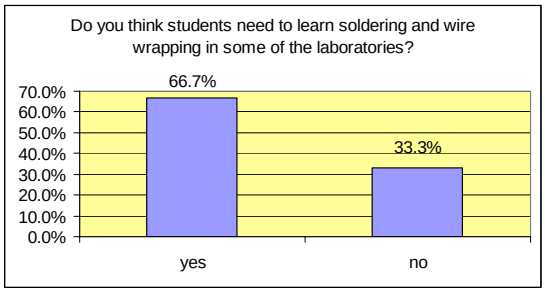
The team-centered laboratory experience focused on active engagement of students during both pre- and post laboratory [9, 10, 11, 12].

Summary of Survey Results and Analysis

The survey instruments were developed for the following groups: students, faculty, part-time faculty, board of industrial advisors, teaching and lab assistants, technology listserv, alumni, simulation software vendors, and campus visits. Students and alumni could not be contacted at the time of this study and they will be included at the end of the second phase of this project.

Faculty Survey: The results can be summarized as follows:

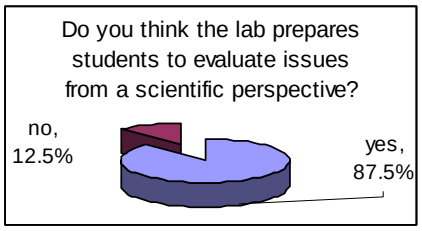
- The faculty requires lab reports for each of their labs.
- Most faculty (80%) do not see the labs as synchronized with the lecture.
- They did not think the labs had enough scientific perspective.
- Majority of faculty think students need to learn practical skills such as soldering.
- The issues that were brought up to improve the labs are:
  - make labs more fun,
  - more project emphasis,
  - more creative labs,
  - less repetition among the lab concepts,
  - less cookbook type of labs,
  - better teaching and lab assistant coordination,
  - more synchronization with lecture,
  - creation of own manuals,
  - less crowded labs,
  - more qualified instructors,
  - more open lab times.



Necessity of soldering as a skill. (Faculty survey)

- Faculties emphasized the instructor enthusiasm and knowledge as the keys to the improvement of student involvement in the labs as well as the need for the lab equipment to be state-of-the-art level.

Part-Time Faculty Survey: All part-time faculties stated that the necessity for the students to know how to do soldering and basic hand tools. Most of the part-time faculties think there is synchronization between the labs and lectures.



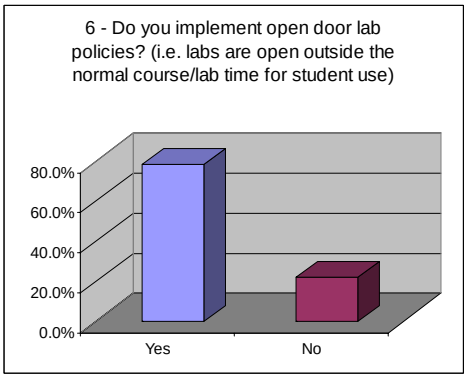
Scientific perspective of labs. (part-time faculty)

Board of Industrial Advisors Survey: Hands-on lab skills were leading in the requirements list. Most of the advisors strongly agreed on the necessity of a project-based learning experience through the labs. The expectations of the board can be listed as:

- communication skills,
- team work on a common project,
- experience extending from ordering of the parts to putting together a final product,
- programming as well as hardware as a whole,
- safety requirements,
- professional quality project report writing.
- In addition, soldering and hand tools skills were voted (by 90%) as a required element of the experience in the labs.

Listserv – Nationwide Technology Colleges Survey: About 59% of the respondents prepared their own lab manuals. Most of the labs were conducted in groups. Most of the schools had an open lab policy as shown in the chart.

About 60% of the survey respondents have their own lab policies. Very small percentage had a web site for their individual labs. About 60% of the respondent schools had a project related to the course.



Open door lab policy. (Listserv survey)

Analysis and Recommendations of the Survey Results

The project team identified the essential ingredients for the labs to be **fun** and promotion of **creativity.** In order to achieve this goal there should be serious consideration on **open labs, enthusiastic mentors,** and periodic **modern equipment** purchasing. There was a great emphasis

on putting **tangible links to the lectures:** lecture/lab can be given by the same lecturer, lecture/lab synchronization can be tested, and course and lab can be combined.

Project component is another indispensable part of the expected education in the CETE program. The design and implementation of project work should include: experience from parts to the final product, teamwork, communication, report writing, hand tools and skills: e.g. soldering, wire wrapping, simulation, software and hardware.

Recommended Simulation Software for CETE Labs

The recommendations below are based on the simulation software survey that inquires about simulation software packages currently available in the department, vendor support, resource availability, cost and licensing agreement. The usage percentages identified from Technology Listserv Survey is: MultiSIM 27.3%, Electronics Workbench 22.7%, PSpice 31.8%, and Altera MAX+II 9.1%. Recommended Simulation software for CLABS is shown in Table 2.

Table 2. Recommended simulation software.

CETE Labs	Simulation software
ELET 1100 Electrical Circuit Lab I	**PSpice 9.1** Simulation software for Analog and Digital circuits
ELET 1101 Electrical Circuit Lab II	**PSpice 9.1** Simulation software for Analog and Digital circuits
ELET 2103 Digital Circuits and Systems Laboratory	**Multisim 7.0 Electronics Workbenc**h, Electronics Workbench is used for circuit analysis, design, simulation and printed circuit board layout for digital circuits **Altera Max + Plus II**, The Altera Multiple Array Matrix Programmable Logic User System development software, is a fully integrated package for creating logic designs, timing analysis, and timing simulation
ELET 2105 Semiconductor Devices and Circuit Lab	**PSpice 9.1** Simulation software for Analog and Digital circuits
ELET 3303 Operational Amplifier Lab	**Multisim 7.0 Electronics Workbench**, Electronics Workbench is used for circuit analysis, design, simulation and printed circuit board layout for digital circuits
ELET 3102 Communication Circuits Laboratory	**Multisim 7.0 Electronics Workbench**, Electronics Workbench is used for circuit analysis, design, simulation and printed circuit board layout for digital circuits
ELET 4108 Senior project lab	**Multisim 7.0 Electronics Workbench**, Electronics Workbench is used for circuit analysis, design, simulation and printed circuit board layout for digital circuits

CLABS Web Site

The Website developed for the CLABS is an indispensable resource for students and faculty[13].Variety of pertinent information and resources were collected in a **CLABS web portal**, shown in Figure 1, during summer 2004 to enable a broad reach and dissemination [14]. It is worth noting that to the best of the team's collective knowledge, the CLABS Website is first of its kind in coverage and breadth. Currently, no other school has such a comprehensive site for all of its laboratories.

Figure 1. A snapshot of the CLABS web portal startup page

The website is currently under construction but many of its links are functional and currently being used in at least three laboratories. There are several links and sub links on each Webpage that further leads the user to other useful information.

Summary and Conclusions

CLABS Project is supported through the ET department and the Dean's office was declared well worth the investment during the faculty meeting and the payout is expected to be very high in the shape of better quality lab instruction, more comprehensibly qualified graduates, and naturally a better reputation of the college in industry.

The project team approached this project scientifically through extensive surveying and resource research and achieved results with professional commitment. Valuable data were collected and analyzed from many important groups. The survey responses were extremely helpful in identification of shortcomings and next steps. The development of the CLABS Website will bring the students, faculty, and the technical staff in the CETE program closer to the main goal of excellent education at the college. With widespread usage, the project team expects to receive additional support and suggestions from all concerned groups.

The continuation of this project into its second phase is not only indicative of the ET department and the dean's office commitment to enhance all programs, but also can be used as a guiding post for other programs in the ET department.

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