Toward Best Laboratory Management Practices

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Abstract

This paper discusses the Laboratory Management (LM) practices at the Engineering Technology (ET) Department of the College of Technology (COT), University of Houston (UH), in the past two years. The paper presents the rationale behind the need for LM team and how it has evolved to an integral administrative component of the ET department. The experience gained and the resulting benefits are enormous in helping the faculty, students, training of the Teaching Assistants (TAs) as part of their professional growth, and providing a seamless interface between the laboratory operations, its staff and the faculty. The LM team follows the guidelines set by the ET department through the Computer Laboratories (CLABS) Project, a departmental sponsored initiative launched in summer 2004, to review and update the laboratory practices in the Computer Engineering Technology (CETE) program. The LM team is also a member of the CLABS team and through its weekly meetings ideas are exchanged and strategic decision made and then reported to the faculty and chair. The significant of the CLABS project was the development of the Laboratory Experiment Model using the Bloom’s taxonomy and use the model as a base to develop experiments in-house. The paper elaborates on the various tasks the LM team is engaged in, the LM web site and shows a significant departure from traditional laboratory setting that still exists in many colleges and universities. Other activity that the LM team participates is the Coordination Of Robotics Education (CORE) Project in the ET department where the annual tournaments of First LEGO® League (FLL) and Botball are organized. Other duties of the LM team includes finding competent graduate students to assist research faculty in the department, train the TAs, supervise daily lab activities, scholarly activities such as grant writing, technical paper publications and annual report to the ET department. The paper concludes by providing short and long term goals for the LM team.

Keywords: Laboratory Management, Curriculum Innovations, Linkages with K-12 Education.

Perceived topic category: Innovations in Laboratory Management.

Introduction

The lab management idea was the result of the study conducted by the CLABS team in 2004. In order to enhance the laboratory operation of the Computer Engineering Technology program, the CLABS team identified several needs including a full time lab manager. The finding of the CLABS team was presented to the faculty and administration and received a unanimous support. Because of
the novelty of the idea and the benefits that would bring to the CETE program prompted the administration to extend the idea to other engineering technology programs. Two lab managers were hired to serve the Computer Engineering Technology and Electrical Power Engineering Technology programs and one lab manager was hired to serve the day to day laboratory operations of the Mechanical Engineering Technology and Construction Management Technology programs. The lab managers worked closely with the faculty and the ET chair to implement the goals outlined in the CLABS recommendations. After nearly two years, the labs in the ET department operate much more efficiently, the graduate assistants serving the labs are much better trained, better synchronization of the labs and lectures are achieved, students are satisfied as they are engaged more, learn more and the labs operations are uniform in their requirements and expectations. In the following sections, the philosophy behind the lab management, the goals and responsibilities of the LM team are explained and other aspects of the lab management are detailed.

**Goals of the Lab Management in the Educational Process**

The office of the ET Lab Management plays an important role in the educational process of the COT students. The Lab Management provides the support to the cognitive process which is initiated in the classroom and completed in the laboratories, creating a real educational environment which is oriented to provide an excellent education to the ET department students. The main goal in this educational process is to create skillful graduate students with aptitudes that today’s job market demands.

**Roles and Responsibilities of the Lab Management**

The LM team is an integral administrative component of the ET department. The LM plays an important role in the laboratories operations by facilitating a real linkage between faculty, students, and administration. Figure 1 shows the roles and responsibilities of the LM team. In the next section,
the laboratory model developed and followed in each lab is explained.

**Laboratory Experimental Model**

The evaluation of previous educational experiences in the ET department showed the necessity to create a new teaching method which would engage the students in the active learning process [1]. This is the main motivation in the lab experiment model: creative lab activities with special attention to *cognitive process* and *diverse learning styles*. The different learning styles are in line with the diverse demographics of ET department. In order to promote the best practices, a hands-on approach is adopted with inquiry-based learning/teaching components with project-based instructions [2].

The goal here is to bring out the strengths in different learning styles through numerous and different teaching components. In addition, educational activities are aligned with the cognitive process of Bloom’s Taxonomy [3]: knowledge, comprehension, application, analysis, synthesis, and evaluation. The learning activities and the targeted intelligences are listed in Table 1. Similar efforts showed that students change the perception of their learning and these effects are related to the level of the learning as defined by Bloom’s Taxonomy.

<table>
<thead>
<tr>
<th>Intelligence</th>
<th>Activities</th>
<th>Learning Levels (Cognitive levels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal/Linguistic</td>
<td>Teamwork, oral/written reporting</td>
<td>Comprehension, evaluation, synthesis</td>
</tr>
<tr>
<td>Logical/Mathematical</td>
<td>Pre-labs, experiment, conclusion</td>
<td>Knowledge, comprehension, analysis, synthesis, application</td>
</tr>
<tr>
<td>Visual/Spatial</td>
<td>Read/create schematic diagrams</td>
<td>Comprehension, analysis</td>
</tr>
<tr>
<td>Bodily/Kinesthetic</td>
<td>Experimentation (hands-on)</td>
<td>Application, analysis, synthesis</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>Teamwork before/during/after the labs</td>
<td>Comprehension, evaluation, synthesis</td>
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The experimental lab model is linked to the educational objectives of the ABET Technology Accreditation Criteria [4] as outlined in Figure 2.
The components of the lab model include:

1. **Objectives:** Specific outcomes with some information on the tasks.
2. **Introduction:** Brief introduction to the subject and the supporting theory.
3. **Pre-lab:** Before the lab session, where applicable, simulation and creation of electrical circuit diagrams, calculation and verification of parameter values.
4. **Parts list and equipment:** Devices, simulation software, and measurement instruments.
5. **Experiment Body:** Implementation and testing procedure for the circuit.
6. **Application:** Real-life example on the main concept of that experiment.
7. **Conclusion:** Analysis of experimental results.
8. **Report:** Data of the experiment and simulations, results, and knowledge evaluation.
Work Philosophy

In order to comply with the vision and mission of the ET department [5] and the college [6], the LM team has promoted and implemented a new culture in the way that ET laboratories are conducted and administrated. This paradigm is based on a new work philosophy supported by a set of principles and practices. The main components of this new philosophy are outlined below.

- Teamwork
- Hands-on expertise
- Adherence to professional principals
- Proactive attitudes
- Continuous learning and training
- Positive work environment
- Win-win activities
- Effective communications

The implementation of this work philosophy are in-line and in support of the accomplishment of the college educational excellence goals. In the next section, the ET laboratories are briefly discussed.

ET Laboratories

The ET department has many laboratories that support several engineering technology programs [7]. Where specifics are discussed in this paper, the CETE program is used as an example. Other programs have similar structures and address their specific programs.

The CETE program has eleven laboratory courses. Each lab is equipped with set of standard bench test equipment and a PC with connection to the internet. The labs are listed in Table 2.

<table>
<thead>
<tr>
<th>Lab Level</th>
<th>Lab Title</th>
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<tbody>
<tr>
<td>Freshman</td>
<td>DC Circuits and AC Circuits</td>
</tr>
<tr>
<td>Sophomore</td>
<td>Digital Systems and Semiconductor Devices</td>
</tr>
<tr>
<td>Junior</td>
<td>Microprocessor Applications, Sensors</td>
</tr>
<tr>
<td></td>
<td>Applications, Communication Systems, Instrumentations, and Embedded Systems</td>
</tr>
<tr>
<td>Senior</td>
<td>Networking and Senior Project</td>
</tr>
</tbody>
</table>

All these labs except for the Semiconductor Devices were developed in-house through the CLABS project initiative [8, 9] and disseminated [10-12].

Other courses in the CETE program that do not have a stand-alone lab component, such as Object-Oriented Applications Programming and Linux Operating System, have extensive applications-based assignments and projects. The general computing laboratories in the college and department are used for these purposes. The lecture rooms for these courses are also equipped with PCs for timely hands-on experimentations. In the next section, the lab assistants recruitment process is briefly explained.
Lab Assistants Recruitments Process

The new vision about goals and departmental educational objectives has necessitated a more elaborate recruitment process in order to identify the best candidates for the lab assistant (LA) positions based upon the labs specific requirements. The search for the best candidate with a specific profile enabled the ET department to verify that the LAs have the educational knowledge required for teaching the labs, some professional experience, and if possible, prior teaching experience or affinity with the educational environment.

The components of this profile provide a significant advantage in the preparation of the LAs. If the candidates have previous experience in the industry and have been exposed to teaching practices, it permits the ET department to limit the training of the LAs to technical aspects as well as more advanced teaching practices through its LM office.

Currently, the recruitment process is viewed as the most critical activities of the laboratory operations in the ET department. The recruitment process includes the following steps:

- Pre-screening
- Pre-selection
- Personal interview
- In-lab practical test
- In-lab oral presentation
- Commitment
- Recommendation to the program coordinator
- Approval

These steps are detailed in [13].

In the next section, the orientation and training sessions of the TAs in the ET department is briefly discussed.

LA Orientation and Training

The lab management organizes and conducts a two, half-day TA orientation and training (O&T) a week before the start of every spring and fall semesters. The success of the O&T in ET led to an internal grant to develop a generic O&T for several other programs at UH. Details of this effort are reported in [14]. A typical list of topics covered in the O&T is given in the Table 3.
### TABLE 3. TA ORIENTATION & TRAINING

<table>
<thead>
<tr>
<th>TA Orientation &amp; Training Session</th>
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<tbody>
<tr>
<td><strong>Day 1</strong> General orientation about responsibilities, procedures, safety guidelines.</td>
</tr>
<tr>
<td>Day 2 Program specific training sessions consist of training on the software used in the labs and hands-on tutorials.</td>
</tr>
<tr>
<td>▪ General Session, welcome and lab managers address the new TAs</td>
</tr>
<tr>
<td>▪ Role of the LAs, responsibilities of the LAs and disciplinary procedures are addressed by the lab managers</td>
</tr>
<tr>
<td>▪ Safety guidelines are provided by the lab managers</td>
</tr>
<tr>
<td>▪ Important teaching guidelines are presented by a faculty</td>
</tr>
<tr>
<td>▪ Tour of all the labs is managed by the ET chief technician</td>
</tr>
<tr>
<td>▪ Measurement techniques by Tektronix staff</td>
</tr>
<tr>
<td>▪ Lab management work philosophy is presented by a guest speaker</td>
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<tr>
<td>▪ LabVIEW training by the National Instruments</td>
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<tr>
<td>▪ Multisim, 8051 µController, MATLAB, PSpice, Verilog HDL, MAX-PLUS and MASM tutorials by senior LAs</td>
</tr>
<tr>
<td>▪ Enhanced learning for students by a senior LA</td>
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</tbody>
</table>

Scenes from the orientation and training session are shown in Figures 3-6.

**FIGURE 3. OPENING SESSION**  **FIGURE 4. TAS AND FACULTIES IN TRAINING**

**FIGURE 5. ADVANCED MEASUREMENTS**  **FIGURE 6. SAFETY RULES AND LAB TOUR**
LA’s Supervision

Once the LA training has been completed the supervision of the LAs plays a key role in the conversion of the knowledge acquired during the training into real actions. In this process the supervisors (LMs) are viewed as a combination of role models, mentors, teachers, interpreter and leaders. The LAs’ supervision is performed through different means. The LMs have implemented a dual way supervision style where the supervisor defines the tasks assigned to the LAs and they provide useful feedback through several instruments implemented for this purpose. Some of them are:

- **Laboratories schedule**: The laboratories schedule includes Regular Labs: assignment of regular labs during the week and Open Labs: Open labs during the morning.
- **Weekly meetings**: LMs meet with the LAs weekly in order to track and summarize the weeks activities, ensure that the guidelines and responsibilities have been completed and receive suggestions or concerns from the LAs.
- **Weekly report**: Each LA provides a weekly report that includes a detailed description of their activities. The summary of all the reports is prepared and used by the LMs to generate their weekly activity reports.
- **Labs detailed activities**: An Excel file is used to track the lab activities as well as information about the lecture in order to ensure the labs and lectures are synchronized.
- **Instructor of Record (IR)-LA meetings**: Each week, the LAs have scheduled meetings with the Instructor of Record (IR) and/or the lecturer in order to review the experiments, potential changes, and verification of the synchronization between the lectures and Labs. A record of these meetings is reported to the LMs.
- **PowerPoint presentation**: At the beginning of each lab session, an introduction to the experiment is presented and a brief review of the next pre-lab is discussed. This is a standard followed by all LAs.
- **Lesson plan**: Each LA has a lesson plan and objective for each lab session as well as approximate time for each laboratory activity. The lesson plan is authorized by the LMs and IRs.
- **Handouts/Outlines**: The labs outlines have complete information about the lab objectives, ABET information, lab polices, contact information, grading polices, and tentative experiments schedule.

Lab Management Web Site

In order to most efficiently manage the day to day operation of the ET laboratories, the LM web site [15] was developed and considered the official site where the students, LAs, faculty and administration staff can find information related to the labs (e.g. experiments, outlines, worksheets, etc.), schedules, forms, and other useful information such as operator manuals for the lab equipment. The LAs report and record their grading through the web portal where they can be checked by the LMs. The web portal also facilitates the standardization of the lab instructions. The homepage for the LM web site is shown in Figure 7. In the next section, the scholarly activities of the LMs are discussed.
LM Scholarly Activities

The LMs are actively involved in many scholarly activities such as publications, grants and other technical and professional venues. They work in conjunction with faculty and administration in all such activities. Grants have been submitted to federal agencies such as NSF and NASA and internally to the University of Houston’s Faculty Development Initiative Program (FDIP). Conference presentations such as ASEE/GSW [11, 13, 14], annual Research and Scholarship Day at UH [16], and other International conferences [17] are examples of other scholarly effort.

LM – Faculty Activities

Most faculties in the ET department are teaching classes that have a laboratory component. As such, the LMs have a close interaction with the faculty and their assistants through meetings in their offices and laboratories where the content of the labs, and possible changes are discussed. All faculties in ET are Instructor of Record (IR) for one or more courses and labs. The suggestions proposed by the IR are then discussed in the CLABS team where all decisions about the laboratories are deliberated. The LM team and the IR work together in order to synchronize the lab and lecture, creating a good synergy in the course-lab offering in the ET department. The lab activities are guided by a lesson plan which is reviewed and approved by the IR and LMs. The lesson plan is also used by the LAs as a teaching reference with the direct contribution of the LMs and IRs. The interaction between LMs and IRs has contributed to the successful instructional delivery of the labs.
LM Outreach Activities

The ET department and the College of Technology are actively involved with many outreach programs and frequently draw on the LM staffs to assist them in the outreach programs. In particular, annual FLL tournament, annual Botball training and Botball tournament, MAES (Mexican American Engineers and Scientists), participation in CORE (Coordination Of Robotics Education) [18], evaluating local high school student projects, giving tours of the laboratories for high school and middle school students who visit the UH campus and others.

LM Curriculum Activities

The LMs are actively participating in few curriculum activities as summarized below.

**CLABS-** The LMs in ELET are part of the CLABS team and have been participating in all of the CLABS’ development work. These developments made the labs more interesting and varied and improved the synchronization of the lectures and labs. The LMs coordinate and supervise the update of the experiments, ordering of the laboratory parts, developing of useful tutorials, evaluating new test equipment, and conduct the midterm and final surveys in several of the labs and the results are discussed in the CLABS meetings.

**Virtual/Remote Laboratories Project.** The purpose of this project is to expose students to the current industrial standards such as LABVIEW, the use of cutting edge laboratory technologies, create a partnership with similar institutions around the world, and promote the participation of the industry in educational activities.

Future Tasks

The LM office strives to improve the operation of its daily activities, implement enhancement to the LM web site, and automate the manual and semi-manual tasks. Few major tasks are planned for the next academic year such as combining the various handouts used during the LA training into a LA Handbook, pilot-testing a hybrid training and LM Newsletter.

Conclusions

This paper addressed the need for the LM in the ET department and explained the various functions and responsibilities of the LM staffs. The experience over the past two years had proven that the LM office is an asset to the ET department and their services are quite effective. Systematic changes implemented and standardization of the laboratories in the past two years and the benefits of those changes were enormous. Having technically and academically qualified and competent LM staffs is indispensable. We highly recommend the addition of the LM office, similar to what was presented in this paper, to all engineering and engineering technology programs.
References


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