

## Web-based evaluation system for a Problem-Based Laboratory

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**Abstract:** The Faculty of Electrical Engineering, University Technology Malaysia is currently moving towards a Problem-Based Laboratory implementation rather than the conventional instructional-based laboratory for final year students. The laboratory has commenced session with about 500 students' registration in the 2007/08/1. The Problem-Based Laboratory requires each group of four or five students to solve three given problems in three different laboratories per semester. Each problem has to be solved by conducting the related experiment within four weeks. As they are various evaluation criteria that need to be considered, a web-based evaluation system is proposed in determining the final grade of the students. The evaluation system allows the laboratory coordinators to log in as administrators in order to monitor the evaluation process, which involves both the laboratory technicians and students. The developed web-based evaluation system has proven its capability in working interactively with the users. From the uploading of student's information, group division, marks insertion and total marks calculation for the final grade. It is anticipated that the web-based evaluation system can ensure reliability and security in determining a student's grade in a Problem-Based Laboratory in a shorter time especially when dealing with a large number of students.

**Key words:** web-based evaluation system; Problem-Based Laboratory; laboratory assessment

### 1. Introduction

Problem-Based Learning (PBL) is a method of instruction that has been practiced and well received in medical schools in various universities all over the world. This is probably due to the nature of studies in Medicine that facilitate the instructors in terms of designing the PBL cases and the students in terms of the effectiveness in acquiring the knowledge and skills required (Azli, N. A., 2004). In the field of Electrical Engineering, the use of PBL as a method of instruction can still be considered as very limited. The PBL method as mentioned by Mehta (2002) has been proven to improve important skills such as analyzing and solving open-ended, real-world problems; finding, evaluating, and using appropriate learning resources; working cooperatively in teams; and communicating effectively, verbally and in writing. In fact, the skills are demanded by the engineering related industry in particular, from their prospective employees. To enhance the employability factor of students undergoing the Electrical Engineering degree programs at the Faculty of Electrical Engineering, UTM, the current program curriculum has included a Problem-Based Laboratory (PBLab) as one of its final year compulsory course. The laboratory is a two credit-hour stand-alone course, which requires at least 2 hours or 3

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hours per week of contact hours in and outside the laboratory respectively.

PBLab involves solving of a given problem that requires the students to conduct certain experiments or laboratory procedures. The new program curriculum has been designed to ensure that enough basic laboratory skills and theoretical background have been provided to the final year students, which will support or enhance their ability to solve the problems. On the other hand, in the final year, the students are also expected to be more independent and matured to indulge themselves in independent learning or discovery learning for problems that require them to do so.

The PBLab has recently commenced at the faculty with about 500 students from seven different programs registering for the course. The students from each program are divided into a group of 4 or 5 people. Each group is required to solve three different problems offered by three different laboratories. Laboratory sessions for each problem are conducted for four weeks which means that per semester the total laboratory sessions is twelve. Assessment for the PBLab includes both individual and group contribution. For the former, the students are assessed on their in-lab activities while for the later they are assessed based on logbook maintenance, presentation and report. In addition, it is also the students’ responsibility to conduct peer and self-evaluation of their group members that also represents individual contribution of each student in a group.

When compared to the conventional instructional-based laboratory, only two criteria have been considered, which namely laboratory report and laboratory performance. Even then, the process of collecting the marks based on ten laboratory sessions has to be done manually and involves a long and tedious task of processing the data itself due to the large number of students. The marks obtained from the laboratory technicians are also subject to their ability to ensure that the marks are correctly recorded without any prejudice. As mentioned above, various criteria will be taken into account in evaluating the students’ performance in the PBLab sessions. Thus a web-based evaluation system specialized to deal with the evaluation process according to the criteria can ensure reliability and security in determining a student’s grade in a shorter time especially when dealing with a large number of students. This paper describes the process involved in the development of the web-based evaluation system. In addition, the strength and plan for future improvement of the system is also highlighted.

2. PBLab assessment criteria

In determining the assessment criteria of the PBLab, a task force was developed at the faculty level to discuss the related issues. This is to ensure that the assessment criteria chosen are in line with the objective of the faculty to produce graduates with not only sound electrical engineering knowledge but also with personal attributes, which are favorable to the industry. Five main criteria were finally decided for the PBLab with percentage distribution towards the final marks as given in Table 1.

Table 1 PBLab assessment criteria

No.	Criteria	Percentage (%)
1	Individual in-lab activities	20
2	Peer and self evaluation	10
3	Group log book	30
4	Group presentation	20
5	Group report	20
Total		100

For Criterion 1, 3, 4 and 5, evaluation rubrics are developed by the laboratory coordinators that allow the laboratory facilitators to rate the students performance, whether as an individual or as a group. Ratings are set to be in the range from 1 to 4 with 1 rated as poor followed by fair, good and excellent for each of the components under each criterion. As the group of students will be assigned to a particular laboratory relevant to their program for four weeks, Criterion 1, for example, has to be evaluated by the facilitators every week. Similarly, Criterion 3 will be evaluated every week after the first week while Criterion 4 and 5 will be evaluated once at the end of the four weeks. Criterion 2 will require the students to submit peer and self evaluation forms that allow them to rate their group members as well as themselves in terms of contribution towards solving the given problem. Only one peer and self evaluation form needs to be submitted by each student at the end of the four weeks laboratory sessions. This evaluation process is repeated when the group of students moves to other laboratories in the fifth and ninth week. The marks obtained from each problem solved at the respective laboratory are then averaged to obtain the final grade for each student.

The technicians at each laboratory is responsible to record the total marks given by the laboratory facilitators based on the evaluation rubrics for all criteria except for Criterion 2. Traditionally, the marks are recorded using Microsoft Office's Excel software. Although this method of recording is acceptable, it lacks in terms of allowing the laboratory coordinators to monitor the recording process. Continuous monitoring is essential to ensure that the marks are not only correctly recorded but also submitted in time based on a pre-determined schedule. Typically, the marks for each problem will be displayed to the students two weeks after it is completed. This is to allow the students to monitor their own progress in the PBLab and consequently improve themselves in solving the future problems. The peer and self evaluation form will be processed by the laboratory coordinators to obtain the marks for each student as evaluated by his or her group members. This process is in fact tedious and time consuming as it requires some calculation involving each student in a group with a total of about 500 students.

### **3. System development**

A web-based evaluation system has been developed to generally support the management of the PBLab. The specific purposes of the web-based evaluation are as follows:

- (1) To allow the administrators to evaluate the students' laboratory performance based on various evaluation criteria, from the marks recording process until the final grade of each student is obtained, with ease and in a short time.
- (2) To allow the administrators to continuously monitor the online peer and self evaluation process conducted by the students and the marks recording process conducted by each technician from various laboratories online, in real time. This allows early detection of problems related to the laboratory implementation.
- (3) To allow the administrators to have continuous interaction with all parties that are involved in the laboratory implementation namely the students, technicians and facilitators through e-mail notices and general notices posted on the website.
- (4) To allow the students to have the details of the laboratory conduct including the formats of each evaluation criteria, report example and template, evaluation rubrics etc. through online access.
- (5) To allow the students to conduct peer and self evaluation of his/her group online without the hassle of submitting forms.
- (6) To allow the technicians to conduct marks entry for each evaluation criteria systematically and effectively after each laboratory project or problem is completed. This will ensure that the students will get their results in

stages that will give them the chance to improve themselves if necessary.

3.1 System architecture

The web-based laboratory evaluation system is developed by integrating web and open-source technology (PHP and mySQL) that can produce a cost effective system without requiring the need to purchase specific data base software and high prestige hardware. The system is designed to be mobile and does not depend on hardware or operation system, which can be quickly and easily accessed without any location constraints as well as modular. Figure 1 shows the structure of the system.

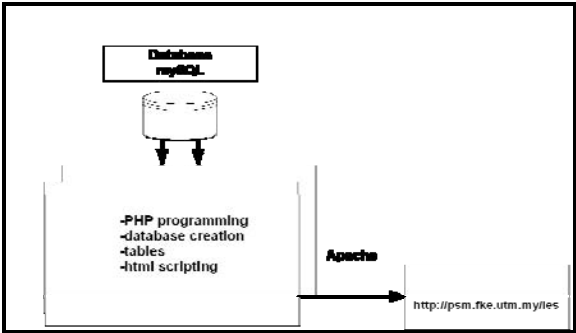


Figure 1 System structure

3.2 Module structure

As shown in Figure 2, the web-based laboratory evaluation system consists of seven modules namely data extraction, student distribution, peer and self evaluation, marks entry, marks, administrative and reporting.

The data extraction module works by extracting students’ data from the university’s Academic Information Management System (AIMS, 2000). The information obtained is placed in a database so that students can conduct peer evaluation of his or her group members. Information on the technicians is inserted manually by the system administrators whom are the laboratory coordinators in this case.

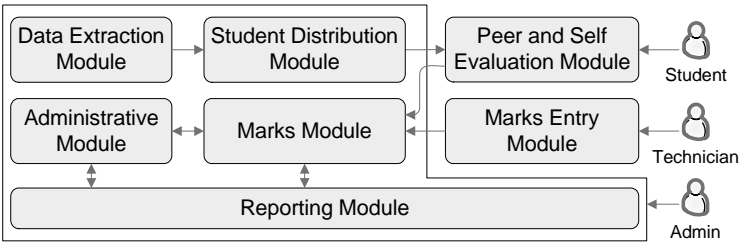


Figure 2 Module structure of the web-based evaluation system

The student distribution module prepared for the administrators. Its function is to distribute the students in each section into groups of four or five, randomly. The module also produces the laboratory timetable of each section based on the three problems at three different laboratories that have to be solved by each group. The peer and self evaluation module, on the other hand, is used by the students to evaluate themselves and their group members based on the evaluation rubric developed by the administrators. Evaluation can be made right after each problem that is completed and opened for submission up until a specified date only, typically the week after.

The marks entry module is accessible to the laboratory technicians only for them to insert the students’ marks for each of the assessment components described earlier. For each problem solved by the students, the marks entry

process has to be completed by the technicians within a specific period, which is to ensure that the students’ marks for each problem can be displayed on time according to the schedule. The administrative module is used by the administrators to monitor the process of entering the marks by the technicians and the submission of the web-based peer and self evaluation form by the students. If after a certain date the marks entry process has not been completed or the peer and self evaluation form has not been submitted by a particular technician or student, E-mail notices will automatically be sent to him or her as a reminder. Administrators also have the authority to delete the record of students who withdraw from the PBLab, update any changes in the students’ record and set or change the deadline for marks to be inserted by the technicians or the peer and self evaluation form to be submitted by the students.

The marks module is also under the administrators’ authorization. Its function is to calculate the total marks and finally grade the performance of the students in the PBLab based on the data submitted by the technicians and students as elaborated earlier. Finally, the reporting module is used to generate the PBLab report in terms of the students’ marks, grades and the related graphs for each section of a program.

3.2 Module screenshots

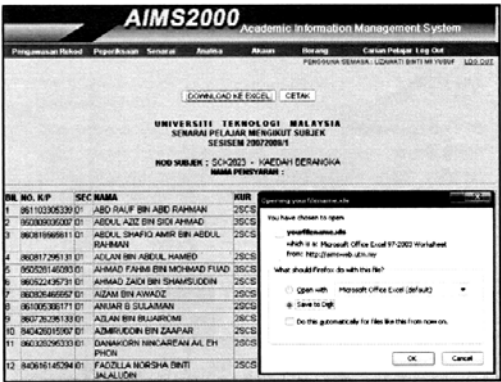


Figure 3 Screen-shot from the data extraction module

Figure 3 to Figure 8 shows the examples of screen-shots generated by each module. Figure 3 shows how students’ data is extracted from AIMS into the database for the web-based evaluation system.

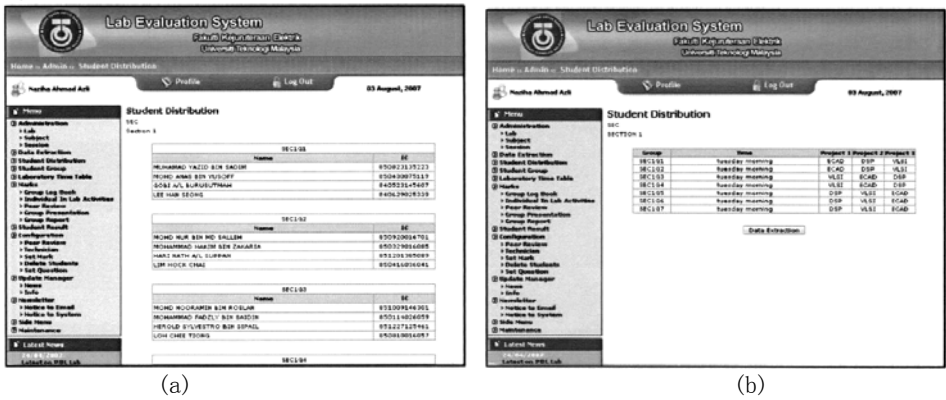


Figure 4 (a) Randomly generated groupings; (b) Semester PBLab time-table

Figure 4 shows screen-shots from the student distribution module for one of the program offered at the faculty, where students randomly generated groupings and the timetable per semester of each group in a section are obtained.

A screen-shot from the peer and self evaluation module is as shown in Figure 5. Once logged in, students have to update their E-mail addresses before gaining access to the form as shown in Figure 5. Students then evaluate themselves and their group members by selecting the marks based on a drop-down menu for each evaluation criterion given before submitting the form online.

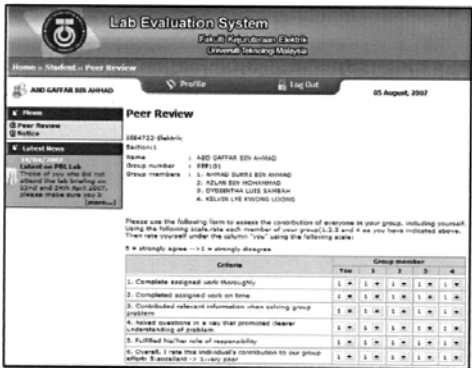


Figure 5 Peer and self evaluation web submission form

Figure 6 shows how marks can be entered by the technicians for both group-based and individual-based criteria in the marks entry module. Both views can only be accessed by the technicians and the administrators for monitoring purposes. Screen-shots from the administrative module are shown in Figure 7.

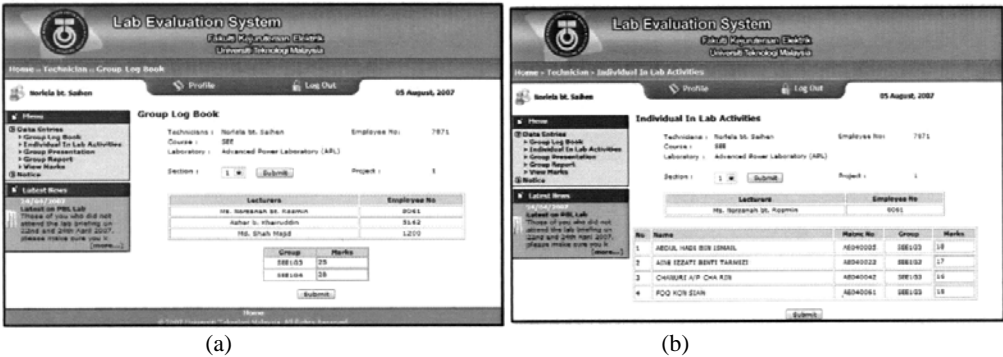


Figure 6 Marks entry module  
Notes: (a) Group-based; (b) Individual-based.

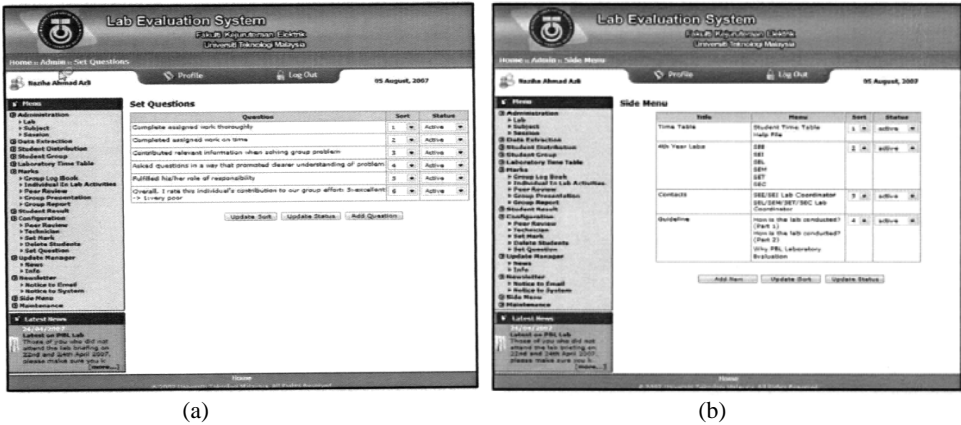


Figure 7 Administrative module  
Notes: (a) Configuring the peer and self evaluation rubrics; (b) Updating the side menu for laboratory conduct information.

The administrative module covers almost every aspect of the web-based evaluation system. It not only monitors the marks entry as well as peer and self evaluation web submission processes, but also has controlled over other administrative tasks such as updating the facilitators and technicians information, programs offering the PBLab, laboratories involved, information related to laboratory conduct, news and announcements. In addition, the administrative module also allows configuration of marks entry and peer and self evaluation deadlines, percentage of evaluation criteria contributing to the total marks and peer and self evaluation rubrics. Students’ data can also be deleted under the administrative module.

In the reporting module, the students’ total marks, grade and the graph related to it can be displayed and printed for reporting purposes. In addition, each student’s marks based on the five evaluation criteria can also be reviewed and corrected whenever errors are detected during the marks entry process conducted by the technicians. Figure 8 shows the screen-shots from the reporting module.

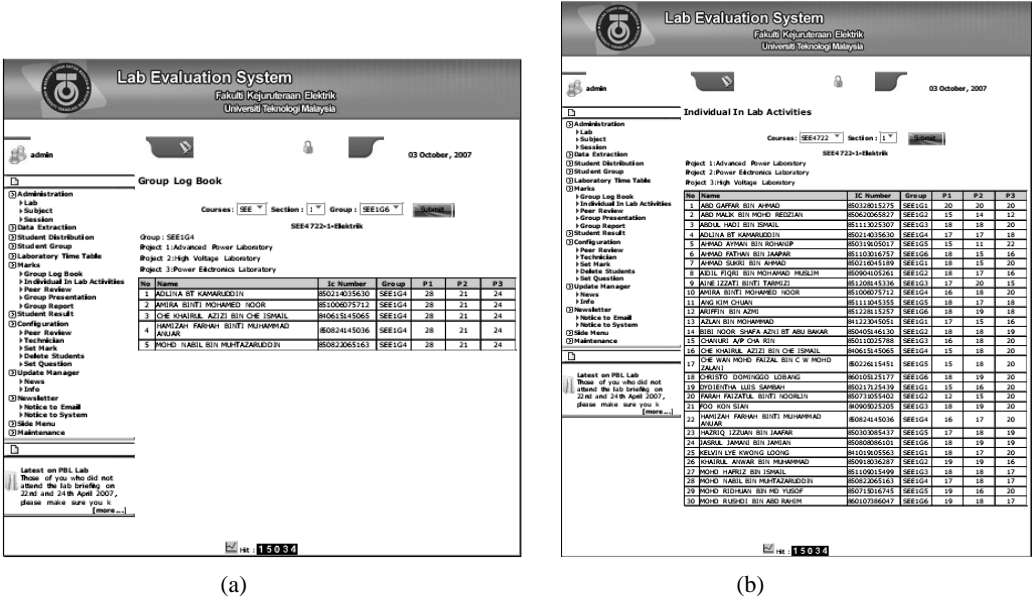


Figure 8 Reporting module

Notes: (a) Group log book marks for each problem; (b) Individual in-lab activities marks for each problem.

3.2 System security

The web-based evaluation system is password secured consisting of three levels namely administrators, technicians and students. The technicians and students can gain access only to specific pages in the system using their password. This is already one of the basic security methods in website programming as suggested by Skrysak (2004) that whereby users should be classified and given features based on that. This implies that if a system is with multiple users who have different roles, such as that of the web-based evaluation system, they should be given functionality based on those roles. There are however future plans to make the system more secure with added features such as the ability to monitor log-in activities and SSL encryption (https:// instead of http://) to better ensure the privacy of the data being sent across the internet at least at the login page where usernames and passwords are submitted to the system.

4. Testing and evaluation

As the 2007/2008/1 semester is still on-going, the performance of the web-based evaluation system has not been thoroughly evaluated. In fact, for security purposes, although the web-based system is used, data related to the PBLab is still recorded manually. However, the functionality of the system has been fully tested, thus verifying its capability in fulfilling its purpose as outlined earlier. Further refining of the system is expected to make it more reliable and capable of reducing the tasks of the laboratory coordinators in managing the PBLab. With the system, manpower requirement for coordinating the laboratories can be reduced up to 50% because it can now be solely handled compared to having two coordinators to manage the laboratories manually.

## 5. Conclusions

The web-based evaluation system for a problem-based laboratory has successfully been developed and tested to support the management of about 500 students that registered for the laboratory. Future years will also be seeing similar number of students enrolling for the laboratory. Thus, the availability of such system will definitely be an added advantage to the faculty in ensuring further enhancement and sustainability of the PBLab. Most importantly, the system allows on-line monitoring of the marks entry process that would help the laboratory coordinators manage the PBLab better which in turn increases the reliability and security of determining the students' grades.

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