# Automatic Evaluation of Student's Performance in Online Laboratories

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***Abstract*—Online laboratories are increasingly being deployed in traditional on-campus as well as Web-based distance-learning courses (distance education) around the world. An online laboratory generally will consist of several experiments (a module). Evaluation of student's performance and grading in laboratory courses involves quiz/viva-voce examinations, checking of experimental data and the submitted laboratory report. The students submit online laboratory report containing experimental data, interpretation, and extracted parameters. The submitted values are automatically compared and graded, with the grading criteria decided by the instructor along with the option of awarding credit for the particular experiment session. In this paper, we describe in detail a proposal on the design and prototype implementation of automatic student performance evaluation and grading system in NetLAB laboratory management system (LMS) currently in use for undergraduate and graduate online laboratories at IIT Kharagpur.**

***Index Terms*—automatic evaluation, online laboratory, grading system**

## I. INTRODUCTION

Advances in communication technology and innovative methods of delivery of instruction have challenged the idea that laboratory courses can only be delivered in a face-to-face conventional laboratory setup. In engineering, for example, online (remote) laboratories are being used to teach thermodynamics, electronic circuits, and other experimental courses as well. Online laboratory are e-learning systems where the learner controls and interacts with hardware from a remote location. Also online laboratories must be operated by a laboratory management system (LMS) that make sure the experiments being performed generate the desired result and also serve the purpose of each individual user. The primary objective of the LMS is to manage learners, keeping track of their progress and performance in experiments. As the numbers of distance learners and distance learning programs increase, the demand for online laboratory will also increase. The impact of Web-based laboratories on higher education is readily apparent.

Online remote laboratories are important in several learning situations such as in the distance learning programs. A recent poll of university administrators showed distance learning to be among the top issues in terms of importance and has been pushed to center stage by the growth of the Internet and the demand for life-long learning. In some cases, experiments in conventional laboratory environments are too costly, time consuming, or difficult to maintain and execute individually. This offers the opportunity for universities, departments, or individual instructors to collaborate in laboratory education. The exclusive self-sufficient university will soon seize to exist, and universities shall have to both think and act globally in order to survive. Internet-based online laboratories located at one educational institution may be shared by another institution. Submission of laboratory reports (individual or group) is a common practice for any laboratory session. However, there are frequently complaints about the grading of laboratory reports. Use of computers to assist assessment of laboratory reports has been an interesting area of research for decades [1,2].

In the context of online laboratory education, quality assurance seeks to balance experiment design, pedagogy, and technology with the needs of learners. Because the quality of educational programs is valued by the administrators, online laboratory courses should reflect a stable and repeatable process. Teaching in an online laboratory class is different from teaching in a traditional laboratory class room, and faculty who often lack the skills to adapt the online laboratory courses to teaching must learn new skills in order to be effective. The acceptance of distance learning technology is not automatic; much skepticism still remains in spite of its effectiveness. In fact, the technological innovations in internet technology and communications have reduced the problems of teacher-student interaction. It is apparent that the emergence of online laboratory education in traditional higher education system will alter teaching and learning contexts. However, there is little research on the effects of these changes. Studying various approaches for integrating communication and web technology for student's performance evaluation is a very important issue which will address the role of online laboratory education. In this paper, we propose an automatic (computer-based) student performance evaluation and grading technique which has been implemented in NetLAB laboratory management system running online laboratories (see Figure 1).

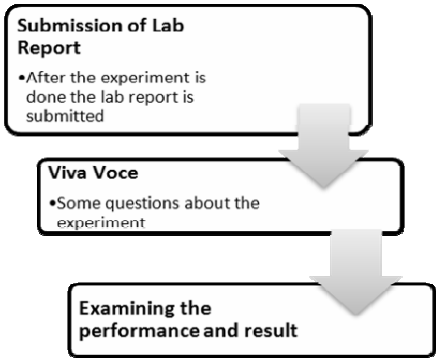


Figure 1. An Ideal workflow for a laboratory evaluation system

## II. STUDENTS ROLE

For proper functioning of the online laboratory, the student's role is very important. Typically a student and the LMS need to interact in the following way:

a) Selection of laboratory experiment by student,
b) System opens laboratory environment,
c) Student joins the laboratory session,
d) System allows the full control of the equipment to the student,
e) Student perform the experiment,
f) Student passes the control to partner to conduct the experiment (in case collaborative learning),
g) Student complete laboratory activities, such as saves data etc. and logs out,
h) LMS closes the laboratory session, and
i) Student completes the learning objectives

## III. EVALUATION STRATEGY

Keeping track of each learner's activities and progress in the laboratory sessions is essential for the instructor. The process of students' performance evaluation (for each experiment) is generally done at several stages, viz,

- Pre-laboratory quiz (after which a student is allowed to book time and perform experiment),
- Submission of the laboratory report after the successful completion of the experiment, and
- Appearing in the Viva-Voce for the experiment.

Once an experiment is successfully performed, the student needs to save the data for analyses. After the completion of the data analyses, the student has to prepare the detailed laboratory report for submission. In the LMS, an online submission facility is provided. The online report submission format contains all the details from the experiment done as well as the data obtained and the analysis. This file is prepared in a particular format. The uploaded laboratory report may be edited by the student for some time after submission. Only the laboratory teacher has access to this report for evaluation and comments. Students are not allowed to have access to reports submitted by other students. After successful submission of the laboratory report, the student can take part in the viva which consists of online true/false, yes/no or short questions. Both these – viva-voce performance and the laboratory report are checked for each experiment performed successfully by a student. Once the student complete the laboratory module (say consisting of 10 experiments), then the final grade of the student is prepared and displayed. Both the student and teacher can only see this grade. Finally, for all the laboratory users, the final grade sheet is prepared and displayed. The instructors can easily keep this information for future reference.

## IV. EVALUATION AUTOMATION

In the following, we describe in detail (see Figure 5), how the above logistics has been incorporated in the NETLab online laboratory management system.

### *A. Preliminary Quiz*

The main motivation of online hardware-based laboratory experiment is to provide the facility to as many students as possible and thus the number of users per instrument is large. It is thus necessary that a user really engages the equipment only when he performs the experiment. This is why a preliminary quiz is proposed and conducted before the learner can get access to the actual experiment webpage and the equipment and/or the experimental setup. This is done primarily to optimize the use of the instruments by making sure that the user is familiar with the instruments and knows about the experiment.

The quiz consists of several random True/False type questions about the instrument, setup, experiment and fundamentals etc (see Figure 2). The user goes through the learning materials, videos, detail of setup etc available for each experiment. When the user is ready to use the instrument, he appears for the quiz. Only after the learner obtains a certain marks (set by the instructor for each experiment), the student is allowed to book the experiment time slot. The student gets the access of the experimental setup during this time.

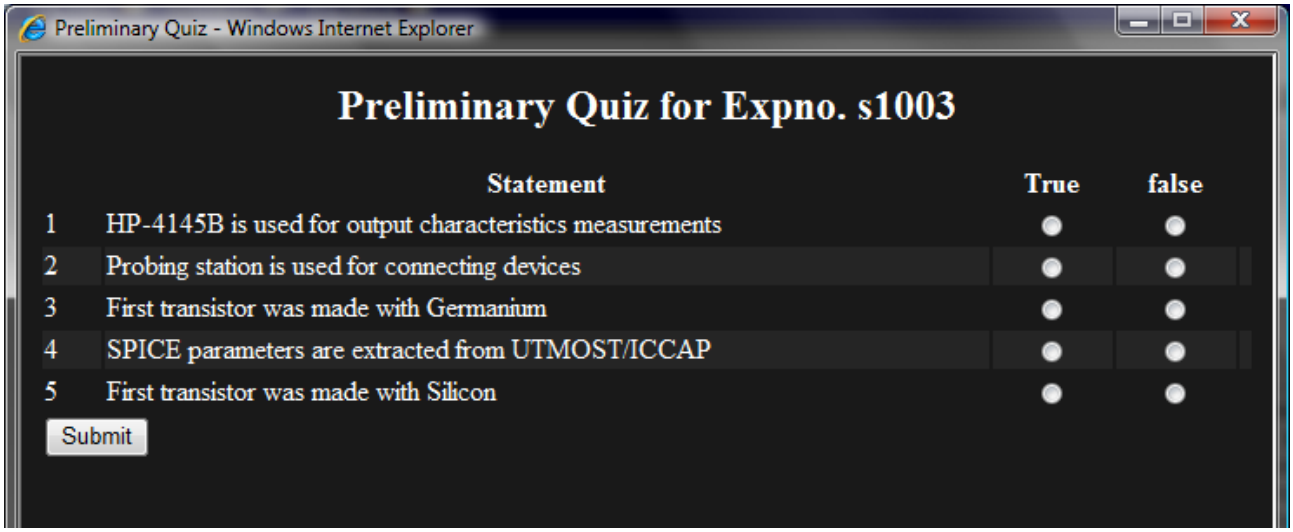


Figure 2. Preliminary Quiz

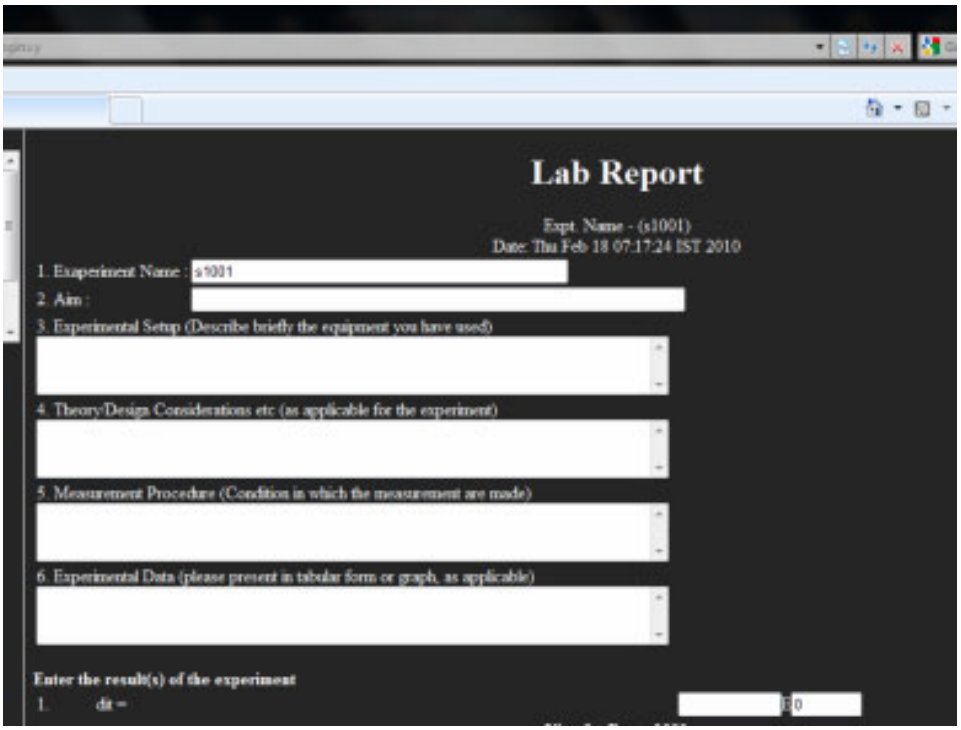


Figure 3. Online Lab Report

### B. *Uploading Laboratory Report*

After the experiment has been performed successfully by the learner, the experimental data is saved and analyzed by the student for the preparation of the laboratory report. This report should contain detail from the experiment, setup, data and the results for parameter values etc. The online laboratory report submission is basically filling in a form (see Figures 3 and 9). After the preliminary section of the laboratory report is submitted, the user has to enter the final results (parameter values) obtained from the analyses. These parameter values are then compared with the pre-set (default) parameter values generated by the instructor. Depending on the off-set (in percentage), the student is given marks and grading is done accordingly. The instructor needs to set some tolerance for evaluation purposes and the system compares the student's uploaded value with the ideal value (see Figure 6). For example, for a tolerance of 10% only, 1 mark will be deducted from the full marks (FM) for the parameter (see columns 4, 5). The instructor may also specify 3 tolerances levels and the corresponding marks that are to be deducted.

## V. SYSTEMS ROLE

The system uses a simple algorithm (see below) to calculate the marks obtained by a student for the parameter values they uploaded. The system is allotted 70 full marks (FM) for the laboratory report. It divides 70 by the number of parameters for that experiment, which gives the maximum marks for each parameter value. So the marks obtained by a student are calculated for each parameter of the experiment and then they are added to get the total marks for the laboratory report.

### A. *Viva-Voce Examination*

Finally, the learner has to take part in the viva-voce. The viva-voce consists of several true/false or multiple choice questions as asked in a conventional oral examination (see Figure 4). The students need to answer them in a certain period of time. The data is matched for correctness and the number of correct answers is determined. The performance is graded accordingly. This value is then added to the laboratory report marks to get the final marks for the experiment.

Algorithm 1:

*For each parameter value (Pi)*
*double a ←The correct value*

*If (Pi == a)*
*Gotnum (i) ← Full Marks*
*Else if (Pi within 1st tolerance range of a)*
*Gotnum (i) ← Marks deducted for 1st tolerances*
*Else if (Pi within 2nd tolerance range of a)*
*Gotnum (i) ← Marks deducted for 2nd tolerances*
*Else if (Pi within 3rd tolerance range of a)*
*Gotnum (i) ← Marks deducted for 3rd tolerances*
*Else*
*Gotnum (i) ← 0*

*finalnum ← finalnum + Gotnum(i)*

*end For*

## VI. FINAL GRADING

A final grade for the student is prepared when all the experiment are performed. Both the student and teacher can see this grade (see Figure 7). The instructors and/or teachers can save this information for future reference. Marks for each experiment are then added to get the final grade report of the entire group of student (see Figure 8).

Some of the advantages are:

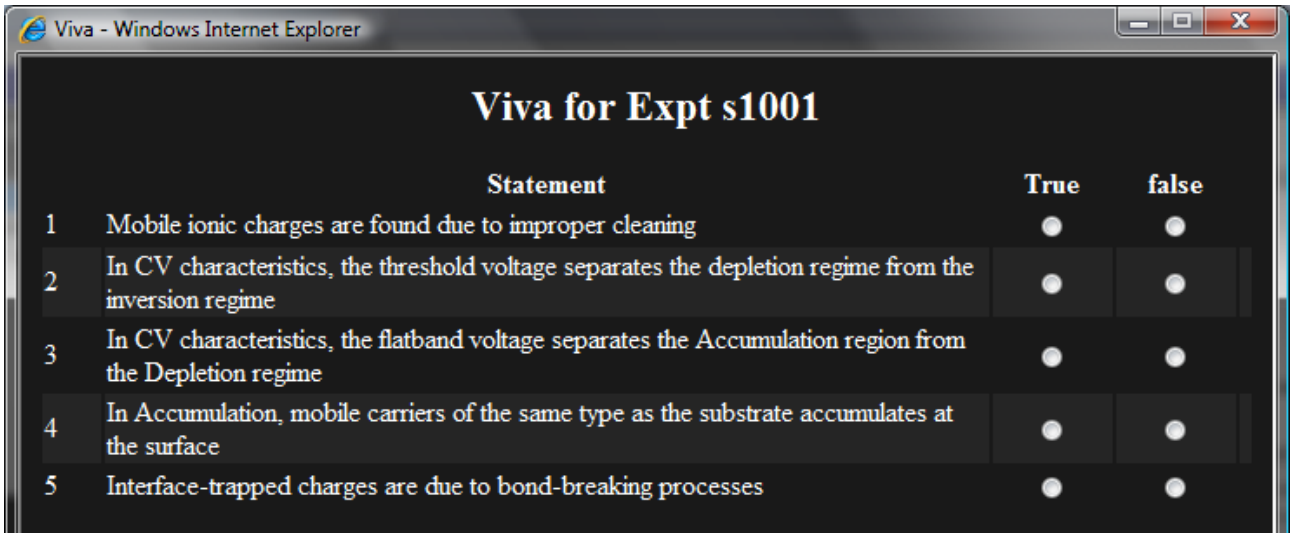


Figure 4. Viva Voce

I. The efficiency of the management system makes the process very fast and can handle a large number of students with accuracy
II. The evaluation of the student's performance is impartial (as there is no manual intervention) and the questions are chosen randomly by the computer

## VII. CONCLUSION

The world of education is facing rapid changes today and will probably face even greater changes in the future. With the emerging communication technologies, such as the Internet, online laboratories are becoming a reality not only in remote areas, but across the world. We propose for the first time an online (automatic) performance evaluation system for grading of students using online laboratories. The module has been incorporated in NetLAB online laboratory management system at IIT Kharagpur. Submission of online laboratory reports has several advantages; an overall improvement of student participation and the benefit may be attributed to increased accountability since the students are graded on the quality of their data presented. For laboratory teachers and teaching assistants, online submission reduces the time spent in grading the report, and offers a more accurate and consistent grading scheme.

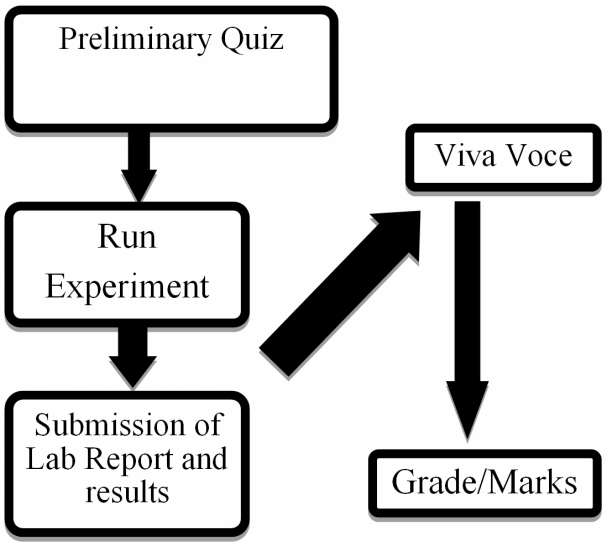


Figure 5. Flow diagram of the automatic evaluation

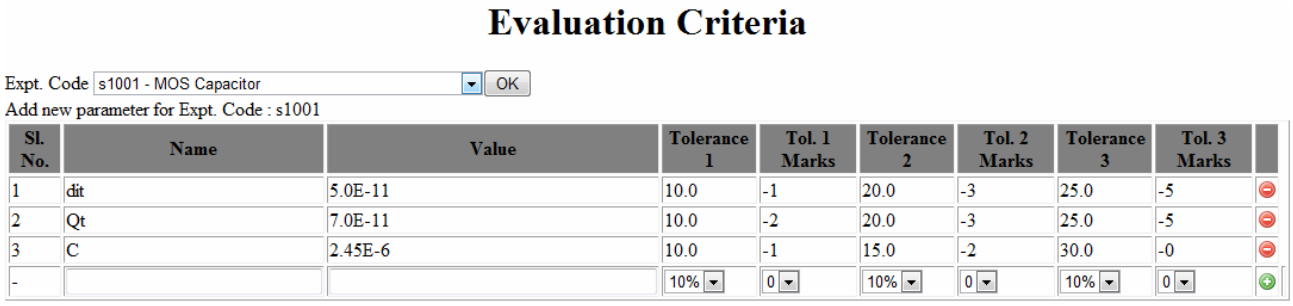


Figure 6. Ideal parameter values (see column 3) for an experiment; students calculate the parameter values from their measured data and upload them. The uploaded values are compared with the ideal values within some tolerance set by the instructor (see columns 4, 6, and 8 for tolerances set for evaluation purposes for this experiment).

Report Sheet for Ananda Maiti (00064)

| Code and Experiment Name | Experiment Performed | Lab Report submitted | Viva (A) (FM 30) | Data uploaded by student | | | | Marks obtained (A+B) |
|---|---|---|---|---|---|---|---|---|
| | | | | Parameter | Offset(%) | Marks | Total (FM : 70) (B) | |
| s1001:MOS Capacitor | Yes | Yes (See Report) | 30 | 1. dit : 5.0E-11 | 0 | 23.3 | - | - |
| | | | | 2. Qt : 6.9E-11 | 10.0 | 18.7 | - | - |
| | | | | 3. C : 1.59 | Incorrect | 0.0 | 42.0 | 72.0 |
| s1013:Emitter resistance | No | | | | | | | Incomplete |
| s1014:Collector Resistance | No | | | | | | | Incomplete |
| s1003:Output Characteristics of a NPN Transistor | Yes | Yes (See Report) | 24 | 1. Current Gain : 43.0 | 20.0 | 28.0 | - | - |
| | | | | 2. Early Voltage : 90.0 | 10.0 | 31.5 | 59.5 | 83.5 |
| s1015:HFE Charateristics | No | | | | | | | Incomplete |

Figure 7. Report Sheet for a Student

| Student Code | s1001 | s1002 | s1003 | Total |
|---|---|---|---|---|
| 00036 | 24.0 | - | 24.0 | 48.0 |
| 00064 | 72.0 | - | 83.5 | 155.5 |
| 001 | 18.0 | 6.0 | 24.0 | 48.0 |
| 004 | - | - | - | 0.0 |
| 005 | - | - | 30.0 | 30.0 |
| 006 | - | - | - | 0.0 |
| 007 | 24.0 | - | - | 24.0 |
| 009 | 6.0 | - | 6.0 | 12.0 |
| 010 | 100.0 | 24.0 | 0.0 | 124.0 |
| 011 | 94.0 | 24.0 | - | 118.0 |

Figure 8. Grade Sheet for the Studnts

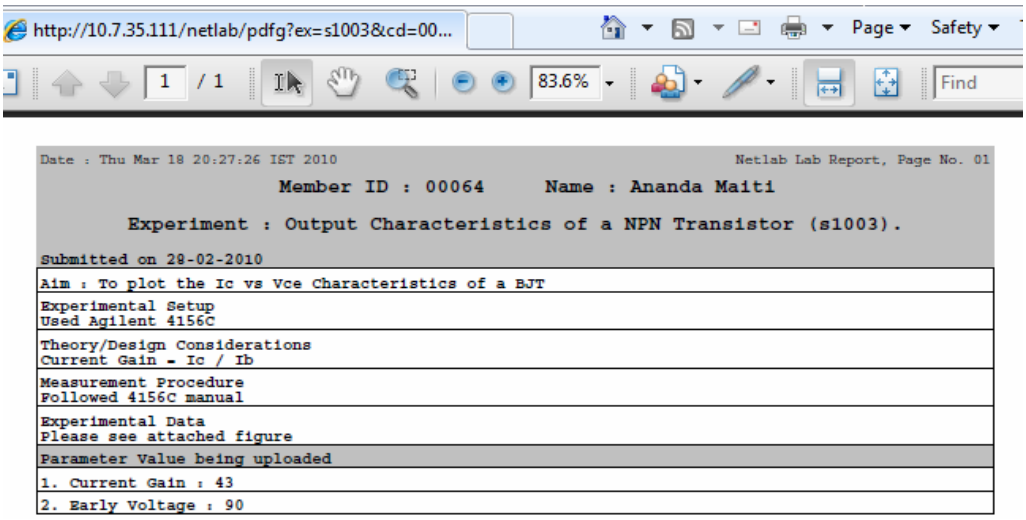


Figure 9. Uploaded Laboratory Report

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