SHARING ONLINE LABORATORIES AND THEIR COMPONENTS

A new learning experience

KJELL O. JEPPSON, PER LUNDGREN, JESUS A. DEL ALAMO*, JAMES L. HARDISON*, DAVID ZYCH*
Chalmers University of Technology, MC2, SE-41296 Göteborg,Sweden,
**Massachussetts Institute of Technology, Cambridge, MA, USA*

1. INTRODUCTION

In this paper we report on the use of the online MIT Weblab system [1] for characterization of semiconductor devices in three qualitatively rather diverse microelectronic device courses offered by Chalmers University of Technology, including junior undergraduate courses as well as extension courses. In particular we will focus on the learning situation and the impact of class size. Since the laboratory equipment is available online 24 hours-a-day every day during the course, new opportunities for integrating laboratories into the learning process have become available. In particular, we will discuss the role of assignment formulation to support this new learning situation.

In this paper we will describe our experiences from using the MIT online laboratory to shift student focus from instrument handling to data analysis, parameter extraction, and model fitting. This can be done through rather open lab assignments where the students themselves can organize the details of their specific task within the context of the overall objective of the laboratory exercise.

2. ABOUT WEBLAB

In a topic like microelectronic device physics the student learning experience can be substantially enhanced by hands-on characterization of diodes and transistors. However, for a variety of practical and economic reasons universities have found it more and more difficult to include such a laboratory component. A remote laboratory available over the internet solves many of these concerns while largely preserving, or even enhancing, the educational experience. Online remote laboratories not only offer the possibility to perform traditional laboratory exercises in a more cost effective way, but they also make available to students more advanced instruments than have traditionally been affordable. Many institutions in different fields have explored this concept of an online laboratory. One such joint European remote laboratory network is presently being developed within the EU Socrates/ Minerva framework [2].

Over the last few years, MIT has been experimenting with a system called the MIT Microelectronics WebLab. This system allows microelectronic device characterization through the world wide web. Through WebLab, students can take current-voltage measurements on transistors and other microelectronics devices in real time from anywhere and at any time. The basic architecture of the system and its use in a variety of educational settings was reported in [3].

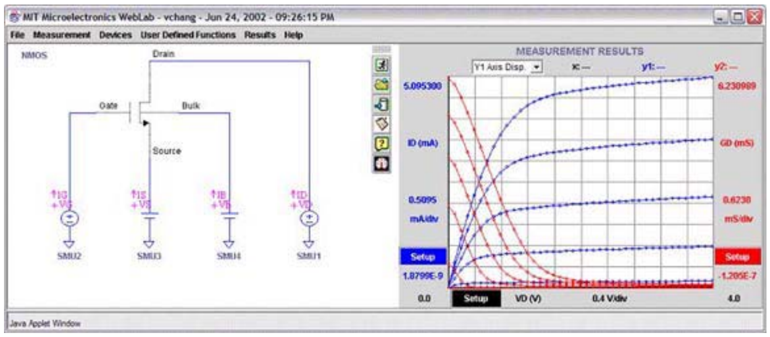

Fig. 1. Screen-shot of WebLab graphical interface: the main window.

The user interface for WebLab is a Java applet which duplicates the essential functionality of the analyzer's console, see Fig. 1, allowing the user to set up a measurement for one of the devices that is currently connected to the system (the necessary information about these devices is provided by the server when the applet loads). When the user is ready to execute a measurement, the applet sends the measurement specifications to the server. More details of the WebLab system and its graphical interface are given elsewhere [4].

3. SHORT DESCRIPTION OF CHALMERS COURSES AND MISSION TASK

The WebLab has so far been used remotely in three different courses offered by Chalmers University. Following two small test runs (one in an elective graduate course (eight users) and one in a extension course offered to professionals working in local industry (six users), WebLab was employed in a large compulsory junior undergraduate course with about 330 students during the spring of 2003.

In all courses students were given a clear objective of the laboratory task and what was expected of them. A simple instruction was given that advanced technology transistors of four different types were available through MIT WebLab.

Examination of the lab assignment in the undergraduate course was performed through group meetings where an examiner directed individual questions to the lab group members who were to respond with the help of a whiteboard. Individual credits were rewarded to the group members according to performance in this oral examination. The communication between MIT WebLab administration and Chalmers course management was conducted by e-mail and for the two small courses the planning could be settled with some ten mails and replies.

4. EVALUATION

The online laboratory experiments were evaluated through detailed discussions with students in the graduate courses and through written review questionnaires handed in by students in the undergraduate course. The overall impression on the use of online laboratories among engineering program students was generally very positive. A summary of the evaluation regarding system access and stability, user friendliness, and educational value is shown in Fig. 2.

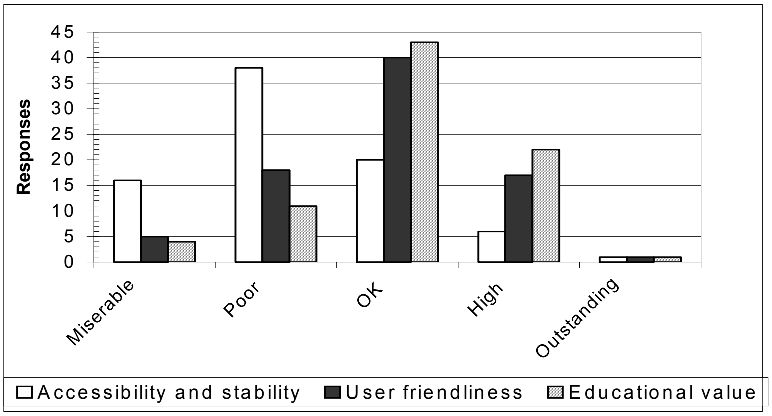

Fig. 2. Summary outcome of evaluation questionnaire.

Students appreciated most that they could decide themselves when to do the laboratory exercises. This was perceived as “less stressful” [than traditional evening laboratory classes]. They also appreciated the graphical interface, because “you could see the graphs clearly” and it was “excellent when analysing data”. The most severe drawbacks were the system instabilities. The system was instable when many students were logged on simultaneously: “First you could not access the home-page at all, and then “once you managed to log in it kept on crashing”.

5. OUTCOME: THE CRITICAL DIFFERENCE OF A LARGE STUDENT CLASS

The use of WebLab in the undergraduate course at Chalmers was the largest and most ambitious deployment of WebLab to date. On Feb 25, 2003, there were 134 characterization experiments executed in a single hour (on average that means a job every 27 seconds). An experiment this scale was bound to result in the identification of new problems that had never been seen before when operating at lighter loads. Two kinds of problems were encountered. First, there was a handful of system blackouts during which WebLab was unavailable for measurements. Second, the system returned an error message in response to a valid experimental setup. The origin of both types of errors was identified and corrected.

6. DISCUSSION AND CONCLUSION

In our experiment with online laboratories we had an explicit purpose to get away from traditional closed-form laboratories. In that type of laboratory students devote most of their time to handling of the instruments to collect device data following a step-by-step instruction manual, frequently asking the teaching assistant for help to find a short-cut to the next step. In an online computer-based laboratory, instrument handling can be minimized through the WebLab graphical user interface. Thereby, the student focus can be shifted to data analysis, parameter extraction, and model fitting. In essence, online laboratories enables the students to take a more active role in defining the scope of the assignment – they can do measurements when they feel ready for them and re-do them when and if need arises [5].

However, new opportunities also mean new challenges, for instance when it comes to finding a text book to support the new learning process. Traditionally, most text books do not contain detailed experimental sections. One exception is the book by Pierret [6] that contains an excellent description of experimental diode setups, but it leaves the readers on their own when it comes to transistor characterization. One wonders who will become the first text book author to include a description of the transistor parameter analyzer in their book?

Some problems encountered in the course of this experiment had a more negative impact on the overall experience of the undergraduate students at Chalmers University when compared to MIT students using WebLab in MIT courses. There are two reasons for this. First, at Chalmers students worked in groups, while at MIT students assignments were of an individual nature. This is relevant because at Chalmers, students had to make an appointment to work together on their lab assignments at a specific time. If the system was not available or if the system did not operate properly at that very time, students were forced to reschedule leading to frustration and possible project delay. In an individual assignment, a student has a lot more flexibility to schedule their work and the consequences of system malfunction are much less severe.

The second reason for the negative impact of systems problems in the overall educational experience of the Chalmer's students is the time zone difference between Chalmers and MIT. As a consequence, several hours could pass between the occurrence of a system problem and its satisfactory resolution, this even if the problem was of a trivial nature and its solution would only take a few seconds.

7. REFERENCES

[1] J. A. del Alamo, J. A., L. Brooks, C. McLean, J. Hardison, G. Mishuris, V. Chang and L. Hui, "The MIT Microelectronics WebLab: a Web-Enabled Remote Laboratory for Microelectronic Device Characterization", World Congress on Networked Learning, Berlin (DE), 2002

[2] R. Cabello *et al*, "*eMerge*: An European educational network for dissemination of online laboratory experiments", ICEE, Valencia (ES), 2003

[3] J. Henry, "Running Laboratory Experiments via the World Wide Web", ASEE Conference, 1996

[4] J. A. del Alamo, V. Chang, J. Hardison, D. Zych, and L. Hui, "An Online Microelectronics Device Characterization Laboratory with a Circuit-like User Interface", ICEE, Valencia (ES), 2003

[5] A. Söderlund, K. O. Jeppson, F Ingvarson, and P Lundgren, "The Remote Laboratory – A New Complement in Engineering Education", ICEE 2002, Manchester (UK), 2002.

[6] R. F. Pierret, "Semiconductor Device Fundamentals", Addison-Wesley, 1996