

CLOUD-BASED TIME-EFFECTIVE LABORATORY REPORTS GRADING

Samuel Kosolapov and Nissim Sabag
ORT Braude Academic College of Engineering
Israel

Abstract

In the frameworks of the described time-effective cloud-based approach, educators are able to prepare a specific laboratory MS Word template file containing an exact list of student assignments to be executed. The student (or pair of students) compiles and finalizes the report during the laboratory by using a computer connected to the Internet. Students log all relevant measurements directly into the MS Word template file. Additionally, students are able to use their smartphones to add photos of important laboratory steps (e.g., oscilloscope' screenshots) to their report as proof of successful execution of relevant laboratory steps. Educators are able to periodically check student' progress. The graded reports are electronically signed and are stored in the cloud.

Introduction

The curriculum for the Bachelor of Science in Electrical and Electronics Engineering includes laboratory experiments as an essential part of the study program. Traditionally, students present Laboratory Reports to the educator as a hand-written or printed paper, whereas educator reads the reports after laboratory is finished. In most practical cases, after the scheduled laboratory is finished, a significant part of the laboratory equipment is re-arranged for the next laboratory. This means that if the educator finds problems in the specific report, the educator can request only minor changes. The student may not be able to provide additional measurements in order to achieve a better understanding of the material studied (and, optionally, appeal for a better grade).

When considering laboratory experiments within the framework of Electrical and Electronics education, it must be noted that, there is a number of student-friendly and inexpensive commercial PC-based electronic circuit simulators (such as "Pspice," "Electronics Workbench," "NI Multisim" and others). Many universities evaluated possibilities of providing electronics laboratories (or parts of them) by using simulations or by using remote laboratories (Auer & Gallent, 2000; Gustavsson, 2003). Despite obvious financial and logistics advantages of using simulations and remote equipment, many educators, including the authors, still insist on providing *old-style* lab instruction. It is strongly believed that hands-on, bench oriented electronics laboratories, with real electronic components (e.g., resistors, transistors, OA, etc.) and standard electronics laboratory equipment (e.g., power supplies, signal generators, oscilloscopes) form an essential part of the electronics engineers' study program. It is essential for the formation of the professional infrastructure of future engineers. Students become acquainted with real properties of basic

electronic components and have initial hands-on experience with the operation of basic electronics laboratory equipment. The processing and analyzing of the results of real measurements significantly assists in student success in subsequent advanced courses and in diploma projects/internships (Sabag, 2002; Waks & Sabag, 2004; Sabag, Trotskovsky, & Schechner, 2006).

During a typical laboratory, students are required to write a laboratory report containing the raw data collected from the experiment. It is clear that compiling laboratory reports in paper laboratory notebooks (PLN) must be considered an outdated and inefficient practice. A number of alternatives to PLN are known. For example, well-known "Evernote" software was used to create *Electronic laboratory notebooks* (ELN) (Walsh & Cho, 2012). Another example is the usage of Google Docs cloud service to effectively manage the data generated by a number of students. Important feature of this service is that files stored in the cloud are not processed by the local (client) computer, but by using cloud computing. This approach provides effective solutions for a number of data-management problems (Bennett & Pence, 2011).

The number of students enrolled in the electronics courses at the author's college has significantly increased in recent years, thus creating a heavy load on electronics laboratories. The authors therefore designed a system to provide time-effective laboratory report management and grading which has been reported in other publications (Kosolapov & Sabag, 2009a, 2009b). The goal of the research was to create tools and techniques enabling the educator to lessen the burden of administrative work (e.g., presence logging, laboratory reports storing, handling and authentication) and thus free more time for focusing on the content.

In this paper, additional aspects of the system that were not reported earlier are described.

Educators and Students Work Organization

In the framework of our time-effective cloud-based approach, the educator prepares the specific laboratory MS Word template file containing a specially designed first page (described later) and a table containing an exact list of assignments to be executed.

Prior to the start of the semester, students register to one of the laboratory sessions within "Laboratory Groups" (each group is labeled by a decimal digit 1 to 9). A typical "Laboratory Group" consists of a maximum of 16 students organized in Pairs/Sub-Groups, (labeled 1 to 9). Laboratory tasks are divided into Assignments labeled 0 to 9. Label "0" is reserved for special purposes.

Upon registration to the laboratory, each pair of students receives a laboratory kit (lightweight plastic box containing a set of cables, breadboards and breadboard-compatible electronic components, according to the list created by educators). This enables the students to carry the laboratory assignments without being dependent on educator assistance. Moreover, students may utilize these kits at their convenience, outside of the official laboratory hours, in an attempt to accomplish tasks that were not finished in due time.

For the purpose of the following description, it is assumed that basic Electronics Laboratory contains at least 10 positions, i.e., one for educator and nine dual student positions, each consisting of a PC connected to the Internet with preinstalled “MS Office” and above mentioned simulation software, e.g., "Multisim," “EWB,” or “PSpice.” Following a short explanation provided by the teacher, concerning the current assignment, each pair of students downloads from the laboratory course site and opens the MS Word Template relevant to the current assignment. While executing laboratory assignments, students log every operation into the template by using plain texts and tables. They describe what they do, by adding screenshots of simulation screens, and adding photos of the assembled circuit connected to the measurement equipment. This is possible because nearly all of our students now have cellular phones equipped with still cameras having resolution high enough to visualize symbols on the screens of the measurement equipment. In cases where hand-written text (for example, manual calculations or graphs) must be inserted into the report photos of scans of the hand-written text can be used, However, most students prefer to use standard computer means, such as “Equation Editor” and “Excel Graph means” for that purpose. Thus, all simulation results, measurements, calculations, and other raw and processed data are summarized in a single MS Word file labeled “Work Report.”

During the final 20 minutes of each laboratory session, students stop their experimental work. They switch to the first “Work Report” page (see Figure 1) and fill in the mandatory fields. Although it is safe to authenticate students by their “Group-Sub-Group” two-digit index, it is recommended that students also fill in the redundant fields specifying their IDs and names. The purpose of this redundancy is to cover situations when students enter a wrong two-digit index. However, in cases where there exists an anonymity policy, for the sake of objective evaluations, those fields must not be filled in. According to our practice, the addition of student photos assists the educator in the grading process, but again, in case of compliance with anonymity requirements, or when a student photo is not available, these fields may be ignored. The template fields up to “Abstract” are self-explanatory and can be freely modified according to educator requirements. However, we found it essential for the students to summarize, in a short abstract (approximately 10 lines), what was done during the laboratory session, and what remains to be done.

1 st Student' ID			1 st Student' Name			1 st Student' Photo					
2 nd Student' ID			2 nd Student' Name			2 nd Student' Photo					
College/University Name											
Department Name											
Laboratory Course Name and Number											
Assignment Name and Number											
Educator' name											
Abstract											
Gr#	SGr#	Ass#	Year	Month	Date	Hour	Min	Sec	Msg	Hash1	Hash2
1	1	3	2008	02	26	16	12	00	00	000	000

E-Signature	113-2008-02-26-16-12-44-00-254-579
-------------	------------------------------------

Figure 1. Example of first page of laboratory template/work report.

In Figure 1, some template fields were resized to decrease figure size. The template is set up in monitor-friendly landscape orientation, allowing for ample field lengths, with no intention to print reports on paper.

E-Signature of the Reports

An important element of the time-effective logistics is the E-Signature. When a specific sub-group of students completes the first page of the “Work Report,” the educator comes to their physical position to review the abstract and may ask questions or asks students to scroll the “Work Report” to validate the assembled data. The educator then electronically signs the report (by using “AuNum” utility described later). The first 15 digits of the signature are self-explanatory and are pre-filled by the students. The last 10 digits (described later) are dictated by the educator, pausing between fields to signal the student to enter a delimiter (“-“) symbol. Usage of delimiters makes E-Signatures readable. All of the symbols of the signature are available on the keypad, so that the signature process requires not more than 15-20 seconds, for each pair of students. Following the signature acceptance, the student copies it to the clipboard (Ctrl-C) and saves the “Work Report” with the E-Signature as filename. Retyping the long signature isn’t necessary: paste, “Ctrl-V” may be used. One of the students in the pair then opens e-mail utility and sends an e-mail to the educator (and to the second student) with the following rules: “Subject” of the e-mail is filled by the E-Signature (again, no need to retype, because the signature is still on the Clipboard, and “Ctrl-V” will paste it in the “Subject” field). The Abstract from the first page is used as message text, and “Work Report” is attached to the e-mail. It is highly recommended, that the e-mail be sent in the presence of the educator in order to prevent undesirable report modifications by students after the educator leaves the position. According to our timing measurements, the entire signature procedure requires not more than 10-15 minutes of the educator's time per group of 16 students.

“AuNum” Utility for E-Signature

E-Signatures are generated by a specially designed “.NET AuNum” software utility. This utility was specially developed as a PC version and as a PDA/Cellular phone version by using “MS Visual Studio C# IDE.” An example of the GUI appearance of this utility is presented in Figure 2. The utility can be easily deployed to educators’ PDA/Cellular phones connected to PCs by using the “deploy” options of the “Visual Studio.”

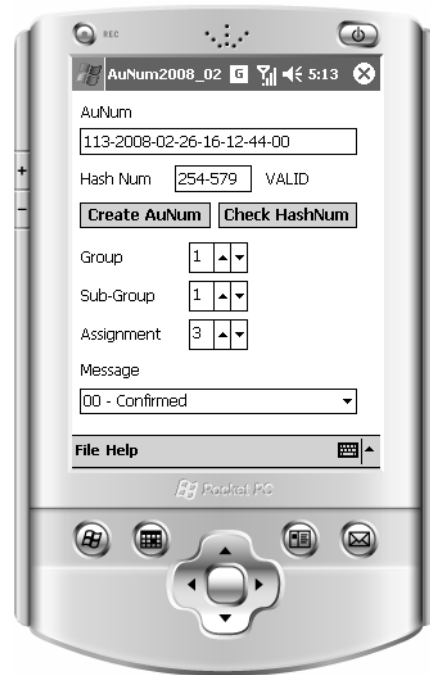


Figure 2. Example of the GUI appearance of the Cellular Phone screen.

In order to create an E-Signature, the educator sets relevant numbers for “Group,” “Sub-Group” and “Assignment.” The “Message” field is used to set “instant indirect grade.” This two-digit message field encodes up to 100 strings to describe students’ work. The default message code is 00 (meaning “Confirmed”). Code “26,” for example, means “Excellent Simulation,” whereas code “43” means “Wrong Measurements.” Codes and correspondent messages are stored in the plain text file. Educator can modify this file in accordance with his personal preferences. The educator may reveal meaning of the codes to students or hide them in accordance of his preferences.

The E-Signature is created by pressing the “Create AuNum” button. Time information (including seconds) is automatically extracted from the educator’s PDA/Cellular phone. The last 6 digits are Hash Code created by using any appropriate algorithm. The next pressing of the “Create AuNum” button will create a different Hash Code (because the seconds were incremented), and thus a Hash Code can be considered as an electronic signature for a specific “Group - Sub-Group - Assignment” index, with an encoded message and a specific time. A Six-Digit Hash Code is enough to meet the chosen goals and short enough for fast entries. However, it is important to understand that the E-signature does not sign the MS Word file, “Work Report.” As indicated earlier, this file can be modified after the signature. Hence it is important to ensure that the file be sent in the presence of the educator. The advantage of this approach is flexibility: “Work Report” can, subsequently, be modified by students and re-signed after explaining what was changed and why. The time-stamp of the E-Signature in this case will clearly be marked in readable form to indicate that changes were made (and accepted by the educator) at a later time. An additional feature of the “AuNum” utility is that all created E-Signatures are stored in the PDA Memory and are backed-up in the educator’s

PC during a routine synchronization process. The E-Signature structure enables easy search and auto-arrangement of uploaded files.

Reports Review and Grading

In addition to “Work Reports,” students compile a number of “Final Reports,” combining data from a number of relevant “Work Reports” with additional sections like “Discussion,” “Simulation-Measurements-Calculation and Comparison.” During the last laboratory meeting of the semester, each sub-group fills out an “Excel Template” (created by the educator) containing the list of all “Work Reports” and latest versions of the “Final Reports.” Upon filling the template, the student automatically sees the expected grade in the column “Student’ grade estimate.” The “Excel Template” is e-mailed to the educator with an assignment number “0.” In order to finalize the grade, the educator checks the validity of the E-Signatures by using the “Check HashNum” button of “AuNum” utility (the label “Valid” appears in case of a valid E-Signature, and “Invalid” appears in the opposite case). The educator finds “Final Reports” by exploiting a search engine of e-mail software using E-Signatures in the “Excel Template,” e.g., "search keyword." The educator finalizes the grade by modifying the “Educator’s grade” column after reading the relevant sections of the reports.

Non-Standard Situations

If, for any reason, E-Signature cannot be provided by the due time, the student can send the report at any other time by setting the last 8 digits as zeros with a relevant explanation in the text of the e-mail. In this case, the educator decides how to grade the student’s work according to prevailing policies. The reasonable redundancy of the templates enables it to cope with human input errors such as e wrong assignment number. If the educator cannot generate E-Signatures by using AuNum utility, any pseudo-random numbers can be used instead of Hash Code. In this case, the educator must manually log the provided signatures.

Discussion

The logistics were tested during 2007-2012 in the laboratories “Introduction to Electronics” and “Analog Electronics.” With slight changes, the same techniques were used during 2010-2015 in the "Image Processing" laboratory. It is important to note that with the exception of 10-15 min required for signatures, all remaining educator time is totally dedicated to “education” – what, how and why students do, and to additional explanations and answers to questions. The logistics effectively avoids possible unpleasantness for the educator and for the student, in situations of a “lost report.” All reports are stored by the cloud e-mail server and can be accessed by the educator from any computer having access to Internet. This flexibility enables educators to utilize their time more effectively. “Strange” appearances of “Subject” field of the e-mail (a 25 digit E-Signature) serves as an additional anti-spam indicator. Practically, a dedicated e-mail address is used for collecting laboratory reports, thus messages with other “Subject” entries must not be opened. Any student appeal can be effectively processed by extracting the relevant report, e.g., by assignment number, by date. At any time, the educator can see a

student's progress by sorting reports by assignment number, which provides immediate information regarding assignment completion. When a number of educators provide the same laboratory for the different groups of the students, responsible for this specific laboratory can monitor student's progress for all groups, quality of their reports and homogeneity of grading in different groups.

Conclusions

The described logistics significantly decreases the time spent on non-pedagogic and administrative chores, e.g., presence checking, report searching and sorting and thus, allows for an increase in instructor-student interactions ("quality time").

The quality of the students' work and reports were found to be significantly better than that of PLN used in the previous years. Strict reporting rules enable better and more homogeneous grading, especially in cases of weak students, through the readily available information regarding the non-implemented elements of assignments. Advanced students may add additional elements into their reports and, for example, provide detailed analysis of possible measurements errors.

Future Improvements

Currently all the logistics, reports structure and software are being re-designed for use with MS Azure cloud services. When finished, this approach will enable any educator to use the described approach by using any modern i-Phone, Android Phone, Windows Phone or tablet without the need to download any extra software.

References

- Auer, M. E., & Gallent, W. (2000). The "Remote Electronic Lab" as a part of the telelearning concept at the Carinthia Tech Institute. *Proceedings of the ICL2000*, Villach/Austria, 28/29.09.2000.
- Bennett, J., & Pence, H. (2011). Managing laboratory data using cloud computing as an organizational tool. *Journal of Chemical Education*, 88(6), 761-763.
- Gustavsson I. (2003, July). *Traditional laboratory exercises and remote experiments in electrical engineering education*. Paper presented at International Conference on Engineering Education. Valencia, Spain.
- Kosolapov, S., & Sabag, N. (2009a). *Time-effective logistics of electronically signed laboratory results reporting*. Paper presented at American Society for Engineering Education Northeast Section Conference. Bridgeport, CT, USA.
- Kosolapov, S., & Sabag, N. (2009b, October). Usage of cloud computing services for storing, handling and validation of electronically signed laboratory reports. *Abstracts of the 5rd ORT Braude College Interdisciplinary Research Conference*, (20), Naharia, Israel.
- Sabag, N. (2002). *Investigating characteristics of project-based learning in electronics* (Theses). Technion, Haifa, Israel.

- Sabag, N., Trotskovsky, E., & Schechner, P. (2006). Internship as an obligatory requirement for the Degree of B.Sc. in Electronic and Electrical Engineering. *ITRE 4th International Conference on Information Technologies* (pp.94-98). Tel-Aviv, Israel.
- Waks, S., & Sabag, N. (2004). Technology project learning vs. lab experimentation. *Journal of Science Education and Technology*, 13(3), 333-342, Kluwer Academic / Plenum Pub.
- Walsh E., & Cho I. (2012). Using Evernote as an electronic lab notebook in a translational science. *Laboratory Journal of Laboratory Automation*, 18(3), 229-234.

Author Details

Samuel Kosolapov

ksamuel@braude.ac.il

Nissim Sabag

nsabag@braude.ac.il