The Electronic Laboratory Journal:
A Web-Based Collaborative Environment for Remote Experimentation

Georgios Fakas, Denis Gillet

Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland,
{georgios.fakas, denis.gillet}@epfl.ch

1. Introduction

In engineering education, experimentation has always been an essential ingredient to sustain learning activities[1]. It is recognized as an efficient approach for students to effectively assimilate knowledge and to develop a professional approach to solve real-world problems. Collaboration is also an essential ingredient in the recipe to create an effective learning environment, as it provides students with the opportunity to discuss, argue, and exchange information or knowledge. The collaboration between students working actively in small groups can help them to work more productively in the laboratory and also to learn more easily. The literature seems to be supporting that social interaction amongst learners plays an important part in the learning process. In fact, it can have a significant impact on learning outcomes[2, 3, 4, 5].

Numerous Web-based collaborative environments are used in education to support Web-based experimentation. For instance, the Electronic Notebook[6] (ORNL) is a Web-based equivalent of a paper research notebook; it supports the recording of information, sketches, text, equations, images, graphs, signatures, and other data on electronic notebook pages, which can be read and navigated in the same way as in a paper notebook. In addition, electronic notebooks allow partners in different geographic locations to share the record of ideas, data and events of the joint experiments and research programs. However, the Electronic Notebook cannot easily be integrated with other Web-based experimentation environments, as it is not developed to be open or reusable. Another widely used cooperative tool in the academic community is the Basic Support for Cooperative Work (BSCW). It uses the Web as a platform for communication and offers a number of functions for supporting collaboration in an educational environment. The basic idea of BSCW is to provide the cooperation partners with a shared workspace on the Internet where they can perform their activities. Although many lecturers and teachers use it, their students find its interface complex and cumbersome to use[7].

In this paper, we define and validate approaches and resources that enable collaborative work in the framework of Web-based experimentation carried out together by students in different geographical locations. We reproduce in a flexible way the teamwork scheme traditionally applied on campus by students running together laboratory experiments or interactive simulation

sessions. The *Electronic Laboratory Journal* (ELJ) GUI metaphor is introduced as a dedicated environment to support over the Internet the collaborative and cooperative activities among a group of students committed to complete a specific experimentation assignment. It includes advanced documentation tools, such as the *Electronic Laboratory Journal Document Editor* and the *Notes Editor*, discussions and experimentation results submission facilities, managing of laboratory sessions, and also educator supervision and tutoring facilities. The system emphasizes the use of content rather than document oriented notes; it enables users to easily edit notes that can contain any format supported by Web browsers, e.g. text, images, graphics, manuscripts, measurements, charts, or multimedia objects. The ELJ enables educators to supervise students' progression with their assignments and provides them with some assistance and tutoring. It also integrates information related with the experimentation preparation.

The ELJ paradigm is currently validated in the framework of the *eMersion* project[8], which aims at developing at EPFL (the Swiss Federal Institute of Technology - Lausanne) hands-on resources for flexible learning in engineering education focusing on remote manipulation of real setups and Web-based simulation. The ELJ is designed to be an open and reusable Web-based application. For this reason, XML[9] and Java technologies are deployed.

The rest of the paper is organized as follows. In the next section, the *Electronic Laboratory Journal* and its functionalities are presented. Section 3 describes an application of the *Electronic Laboratory Journal* and its validation in the *eMersion* framework. Section 4 presents the different implementation technologies employed. The paper ends with concluding remarks.

2. The Electronic Laboratory Journal

The *Electronic Laboratory Journal* (ELJ) is an electronic and enhanced version of the traditional laboratory journal used by students during their laboratory sessions, where students can collaborate and cooperate by maintaining and sharing *notes* in order to remotely document, complete and finally submit their practical teamwork (see figure 2). The ELJ enables the Web-based execution of such activities by providing a common workspace for each laboratory assignment of each team, i.e. the *Electronic Laboratory Journal Document* (ELJD).

The ELJ metaphor was chosen, as we believe that engineering students are familiar with this concept and it is easy for them to use and conceptualize. A number of requirements have been defined for the design of the ELJ. The first and most important requirement was to keep the system simple by avoiding the addition of extra functionalities not explicitly required. The included functionalities were carefully selected. The ELJ is simply a dedicated environment to be used by a group of students to carry out a specific teamwork. It does not include specialized collaborative functions, e.g. advanced discussion facilities, teleconferencing, calendaring, etc. A second requirement was to encapsulate and emphasize in the ELJ design, the whole cycle of an experimentation teamwork; i.e. study of any required preparatory material, scheduling, educators' supervision and tutoring, execution of work, and finally results submission. A third requirement was to enable students to edit in a flexible way Web-based documents that contain many formats of objects such as text, images, graphics, charts, manuscripts, measurement logs, simulation results, or any other multimedia objects. Another important requirement was to develop an open and reusable system that could be integrated into other experimentation

environments in engineering, or even applied in any educational area where students have to perform group work.

2.1. The Electronic Laboratory Journal Functionalities

The functionalities of the ELJ are classified into the three types of roles it supports, i.e. educators, students and groups. The students are members of a group, and they submit their results as a group. The *Electronic Laboratory Journal* provides students with the following functionalities:

- **Open ELJD**, the user can open and edit existing ELJD.
- **New Note**, activates the *Notes Editor* tool, which enables the users to edit notes.
- **Edit Task Note**, the students can edit existing task notes.
- **Reply to Note**, the students can reply to notes; this functionality facilitates discussions.
- **Submit Task**, when a task is completed, the students can use this facility to submit it to their educator. For a given labwork assignment, a team usually submits different tasks.
- **Delete Note**, the students can delete an existing note.

The educators are either lecturers or tutors. They deal with the teaching of courses or tutoring of teamwork. The system provides educators with a global view of all ELJDs. In this way they can observe each group's progression with their teamwork and also access the submitted tasks for evaluation. The educators can have different useful views of ELJDs, e.g. views by group or by lab assignment, views of submitted tasks, etc. The system also enables educators to communicate with students, in order to tutor and assist them, by creating or replying to ELJD notes (in the same way students do). It must be stated that educators do not have access to all ELJD notes but only to those they are given access by the authors. The system provides educators with the **New Assignment** option to activate the ELJD editor**,** which assists them to define and create a copy of an ELJD for a new teamwork assignment, for each group. The ELJD editor also enables educators to include in the ELJD any supplementary information about the current experimentation (such as experimentation objectives, protocols, theory, etc.).

2.2. The Electronic Laboratory Journal Document

The ELJD is created by the educators (by using the *Electronic Laboratory Journal Editor*) and initially includes information about the lab assignment and its required deliverables (Figure 1). The group members can then start working on this document by composing notes, as they are progressing with the completion of their lab assignment (see figure 2). The ELJD is accessed by the group members; also the educators might be given access to some parts of it.

The ELJD consists of two parts. The first part includes descriptive information about the lab assignment defined by the educator, such as a unique ELJD identification, the name of the lab assignment, the course name, the group name, the starting date and the deadline (if any) of the lab assignment and any supplementary information defined by the teacher.

The second part is the shared space where students work; it consists of a series of notes created by the students in order to document their work and also to collaborate. A note is the simplest form of messages that students can maintain in the ELJ. The ELJ supports two different types of

notes, i.e. *plain* and *task notes*. Plain notes are mainly used for communication or even discussions between the students of the group and their educators. Task notes are used to document the results of the tasks, and they might be in two states, i.e. active or submitted. The students may edit active tasks for a number of times until completion and submit them to their educators. The submitted task notes are automatically viewed and accessed by educators for evaluation. Each note is associated with meta-data, such as subject, type (e.g. plain or task note), status (e.g. active or submitted), date-time of creation, author of the document, and the set of users that can view it.
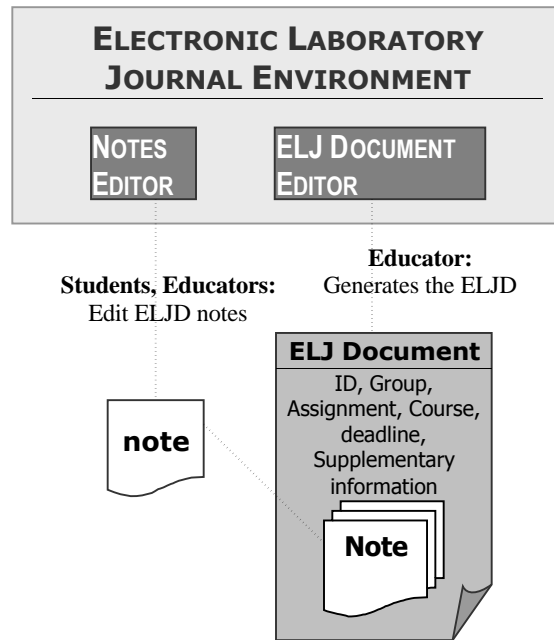

Figure 1. Components of the *Electronic Laboratory Journal* environment.

3. Application of the ELJ in the *eMersion* Framework

The ELJ is currently applied and validated in the *eMersion* framework. The *eMersion* project supports Web-based experimentation facilities for three engineering courses, i.e. Automatic Control, Fluid Mechanics, and Biomechanics. These courses are taught to students from several engineering majors at the Swiss Federal Institute of Technology - Lausanne (EPFL). Traditionally, each of these courses is partitioned into theoretical and hands-on experimentation sessions, *i.e.*, lectures and (virtual or real) laboratory exercises. The aim of applying the *eMersion* paradigm in engineering education is to add flexibility to the students' experimental work and to better integrate complementary activities, such as lecture, exercises and laboratories. Special lab assignments describing hands-on experimentation modules are provided online as complementary support to the lectures. Each module includes the necessary components to carry out a laboratory session. The *eMersion* environment allows students to execute the tasks of any given module remotely. Hence, the students have the possibility to carry out an experiment at a time and from a location of their choosing, and therefore benefit from a more effective cognitive experience.

The *Cockpit* metaphor introduced as a graphical user interface (GUI) includes two main components: The *Experimentation Console* and the ELJ. The experimentation console sustains the students' interaction with the real or virtual experiment and enables changes to be made in the configuration algorithms or parameters. The modifications are graphically displayed as soon as possible. As an example, Figure 2 shows the cockpit that is available to complete an experimentation assignment in automatic control. In this case, the cockpit is dedicated to the Modeling of a mechatronic system that is visualized within the central video frame of the console. The cockpit allows students to easily copy and paste their results into the ELJ (the cockpit currently produces output in text format). Students can also access directly the ELJ and the ELJDs of their choice without visiting the cockpit first. The experimentation console in conjunction with the ELJ can provide students with a remote experimentation environment that enables them to collaborate and to complete their teamwork while being in different locations. The following subsection describes how the two joined environments are used by a group of students in order to remotely work on their experimentation teamwork.
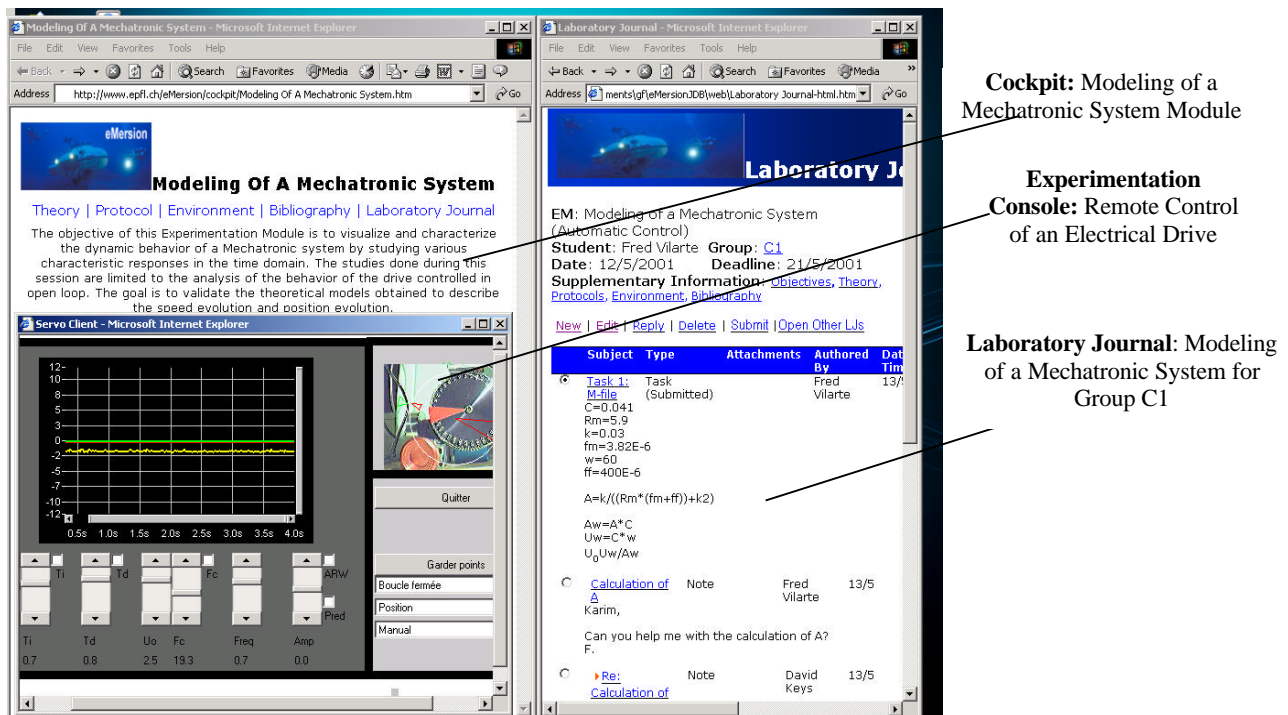

Cockpit: Modeling of a Mechatronic System Module

Experimentation Console: Remote Control of an Electrical Drive

Laboratory Journal: Modeling of a Mechatronic System for Group C1

Figure 2. The eM*ersion* cockpit, including the *Electronic Laboratory Journal*.

3.1. The Case of the Mechatronic System Modeling

One of the modules that any student attending the Automatic Control course must complete is the modeling of a mechatronic system. The pedagogical objective is to visualize and characterize the dynamic behavior of an electrical drive by studying various typical responses in the time domain. The studies done during this session are limited to the analysis of the behavior of the drive controlled in open loop. The goal is to validate the theoretical models obtained to describe the speed and position evolution. In addition to the theory reminder and the description of the experimentation environment, the cockpit composed for this experimentation assignment

contains an experimentation protocol as supplementary information. The experimentation protocol is divided into two parts. The first part is the *prelab* that has to be completed and submitted before being granted with the right to carry out the actual experimentation. The second part is the *labwork* itself.

The *Electronic Laboratory Journal*, as it has already been stated, can remotely support the whole life cycle of lab teamwork. The students start working on their *prelab* by exploring the available experimentation preparatory content included in the cockpit and the ELJ. They study the objectives, theory and then agree on how to fragment the protocol tasks among them. The design of the ELJ system emphasizes the fact that the students first agree on the task allocation, and then work individually on their own parts.

Figures 3 shows the ELJ associated with the *prelab* completed by a group named C1. This group consists of two students, i.e. David Keys and Fred Vilarte. They start their cooperation by studying the lab assignment and its objectives, before agreeing on how to share the work between them, e.g. Fred prepares tasks 1 and 2, and David prepares task 3. The two students use the ELJ in order to work remotely on their assigned work. They edit task notes to document the task results, e.g. *Task 1:M-file*, *Task 2:Values A, tau*, *and Graph* and, *Task 3: U*. ELJ also emphasizes the need of collaboration between the group members; students post questions to each other, e.g. Fred is asking for some help by posting the note *Calculation of A,* and then David responds with the note *Re: Calculation of A.*
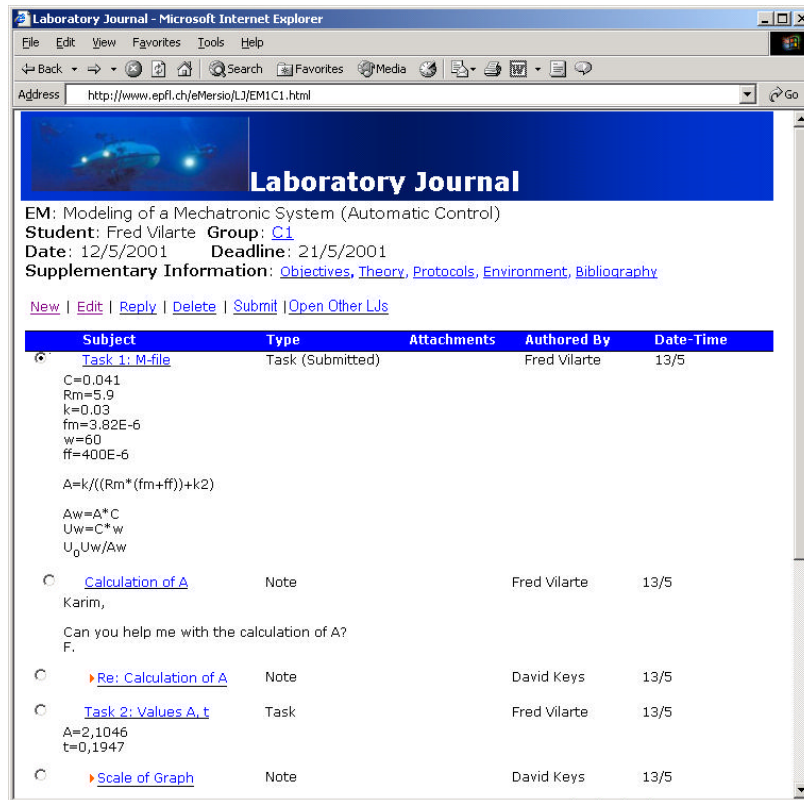

Figure 3. The ELJD Produced as *Prelab*.

After filling in the *prelab* report, the students can use the remote manipulation of real setups and Web-based simulation facilities available within the cockpit to execute their *labwork* tasks and then document each task results in the ELJ.

The role of educators during the completion of modules can be very active and important. The ELJ enables educators to observe closely how team members progress with their work by viewing the content of ELJD task notes and providing the appropriate guidance. ELJ also enables students to request some assistance from their educators and receive responds from them. For instance David sends the note *Scale of Graph* to educator Denis Gillet (Figure 3).

4. Implementation Platforms

The ELJ has a client/server architecture allowing the users to access the system over the Internet through any browser. The ELJ is an open and reusable system, and it is integrated in the *cockpit* as an independent component, presented in a different window. A Web-based user interface is implemented. The system delivers a dynamic HTML document by using Java Server Pages[10] (JSP). JSP achieves the delivery by accessing the Java classes located on the server. JSP technology enables the rapid development of Web-based applications that are platform independent. The server site of the system is implemented as a Java Application[11]. The Java classes include the whole system functionalities; they are responsible for the interaction with the client (i.e. responding to the JSP calls), and also for accessing the XML documents by invoking DOM. By using DOM, the XML documents can be converted into objects and then easily maintained. The system integrates ELJD as XML documents and notes as its tags. XML tags are also used to structure ELJDs and notes meta-data. The notes content is maintained in separate HTML documents.

5. Concluding Remarks

In this paper, an *Electronic Laboratory Journal* (ELJ) is proposed as a collaborative and cooperative paradigm for remote experimentation in engineering education. The ELJ allows a group of students to work remotely in order to complete experimentation assignments by discussing, exchanging or sharing information and also by documenting and finally submitting their results to the educator. The ELJ supports the generation of multi-format notes that may be consist of text, images, graphics, manuscripts, etc. The *Electronic Laboratory Journal* also facilitates educators to remotely supervise, assist and tutor the progression of students with their teamwork.

In this paper, the application and validation of the ELJ paradigm in the framework of the *eMersion* project has also been presented. *eMersion* provides an integrated Web-based experimentation environment that supports remote manipulation of real setups and Web-based simulation.

Acknowledgment

Bibliographic Information

1. H. A. Latchman, Ch. Salzmann, S. Thottapilly, and H. Bouzekri, "Hybrid Asynchronous and Synchronous Learning Networks in Distance Education", International Conference on Engineering Education, Rio de Janeiro, Brazil, 1998.
2. Z. L. Berge, and M. Collins, "Computer-Mediated Communications and the Online Classroom: An Introduction", In Z. L. Berge, and M. Collins (Eds.), Computer Mediated Communication and the Online Classroom, Volume One: Overview and Perspectives (pp.1-10). New Jersey: Hampton Press Inc, 1995.
3. D. Eastmond, and J. Ziegahn, "Instructional Design for the Online Classroom", In Z. L. Berge, and M. Collins (Eds.), Computer Mediated Communication and the Online Classroom, Volume Three: Distance Learning (pp.29-36). E, 1995, New Jersey: Hampton Press Inc, 1995.
4. L. Harasim, "On-Line Education: A New Domain", In R. Mason, and A. Kaye (Eds.), Mindweave: Communication, Computers and Distance Education. (pp.50-62). Oxford: Pergamon Press, 1989.
5. D. Jonassen, M. Davidson, C. Collins, J. Campbell, and B. Haag, "Constructivism and Computer-Mediated Communication in Distance Education", The American Journal of Distance Education, 9(2), 7-26, 1995.
6. Electronic Notebook Project, ORNL, http://www.epm.ornl.gov/~geist/java/applets/enote/
7. K. Klockner, "BSCW - Educational Servers and Services on the WWW: How shared Workspaces Support Collaboration in Educational Projects", International Distance Education and Open Learning Conference, Australia, 2000.
8. D. Gillet, and G. Fakas, "eMersion: A New Paradigm For Web-Based Training In Mechanical Engineering Education", International Conference on Engineering Education (ICEE), Norway, 2001.
9. E. Harold, "XML Bible", IDG Books, USA, 1999.
10. Avedal et al, "Professional JSP", Wrox Press, 2000.
11. M. Morrison, "Java 1.1 Unleashed", Third Edition, MacMillan Computer Publishing, 1997.

Biographical Information

George Fakas is a post-doctoral research associate (ERCIM fellow) at the Institute For Automatic Control at the Swiss Federal Institute of Technology - Lausanne (EPFL). He was born and raised in Nicosia, Cyprus. In September 1993, after completing his military service, he left for England to continue his studies in Computer science. He holds a BSc. in Computation, an MPhil and a PhD from the Department of Computation, UMIST. His research interests include Distance and Collaborative Learning and also Workflow Management.

Denis Gillet is Associate Professor at the Swiss Federal Institute of Technology - Lausanne (EPFL). He received the Ph.D. degree in Control Systems in 1995 from EPFL. Dr. Gillet is the leader of the *eMersion* and *Mentors* projects, multidisciplinary efforts at EPFL that provide a flexible learning environment for carrying out virtual and real experiments via the Internet. His research interests include optimization of dynamic systems, new learning technologies, augmented reality for sustainable interaction, and real-time Internet services.