Real-time Collaboration for Web-Based Labs

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Abstract: Web–based labs are key tools for distance education that help to illustrate scientific phenomena which require costly or difficult-to-assemble equipment. We propose the extension of two open source tools: (i) the learning management system Moodle, and (ii) the application to create web–based labs Easy Java Simulations (EJS). Our extension provides: (i) synchronous collaborative support to any lab developed with EJS (i.e., existing labs written in EJS can be automatically converted into collaborative with no cost), and (ii) support to deploy synchronous collaborative labs into Moodle. Thanks to our approach, students and/or teachers can invite other users enrolled in a Moodle course to a real-time collaborative experimental session, sharing and/or supervising experiences at the same time they practice and explore experiments using labs. The experimental evaluation of our work shows statistical significant (i) increase in student engagement and (ii) higher exam grades for students trained with collaborative labs.

Introduction

It is commonly accepted that digital media (such as simulations, videos, interactive screen experiments or web labs) can positively impact student knowledge, skills and attitudes (Kozma, 1994). Consequently, tools such as *Learning Management Systems* (LMSs) and *web-based labs* have become widespread in distance education in the last decade. LMSs support the administration, documentation, tracking, and reporting of training programs, classroom and online events (Ellis, 2009). Web-based labs make possible to illustrate scientific phenomena that require costly or difficult-to-assemble equipment (Chang et al., 2005). There are two complementary approaches for web-based labs:

1. *Virtual Labs* provide computer based simulations which offer similar views and ways of work to their traditional counterparts (Guimaraes et al., 2011). Nowadays, simulations have evolved into interactive graphical user interfaces where students can manipulate the experiment parameters and explore its evolution.
2. *Remote Labs* use real plants and physical devices which are teleoperated in real time (Wannous, 2010).

Even though constructivist web learning environments and Virtual/Remote Labs (VRLs) already exist, there is still a lack of: (i) convergence and interoperability between both tools (Gravier, 2008), and (ii) real-time interaction between users when they work with VRLs (Gravier et al., 2008; Ma & Nickerson, 2006) and/or within a LMS. We consider that several advantages could be achieved covering these two drawbacks, especially for distance education of practical experiences in technical or scientific subjects. This paper presents a new approach that solves this scientific gap. Currently, there are two different types of collaborative environments according to the moment when the student-student (or student-teacher) interaction takes place: asynchronous and synchronous (Bafoustou & Mentzas, 2002). The first ones allow data exchange in flexible timetables and remote access to web-based course materials to carry out activities in an asynchronous way. They use collaborative tools such as e-mail or forums for on-line communication. This is the typical approach and tools offered by most classic LMS. However, this type of communication can cause feelings of isolation in the student and hence reduces his/her motivation (Boulos et al., 2005). Furthermore, students do not receive instant feedback from their questions and cannot talk in real-time about results obtained in the learning activities. These limitations have been solved by applying synchronous technologies (Marjanovic, 1999), as we have performed in the approach presented in the paper.

It is from the intersection of these previous ideas that the concept of synchronous collaborative VRLs deployed into LMSs is born. The approach presented is based on in this concept by means of the use of two valuable software applications for e-learning and VRL development: Moodle and Easy Java Simulations (EJS). Moodle is a widespread used LMS (more than 50 million registered users, according to its official webpage) that supports constructivist learning, offering its users communication and interaction facilities. EJS (Christian & Esquembre, 2007; Christian et al, 2011) is a tool designed for the creation of discrete computer simulations. During the last few years, EJS has grown for helping to create web-accessible labs in control engineering education. With this objective in mind, recent releases of EJS support connections with external applications, such as LabView and Matlab/Simulink. Hence, EJS not only is useful to create virtual labs, but also the GUIs of their remote counterparts (Heradio et al., 2011).

This paper describes an extension for Moodle and EJS we have developed to provide synchronous collaborative support to any VRL developed with EJS, i.e., thanks to our extension, any existing VRL written in

EJS can be automatically converted into a collaborative lab with no cost. Our approach not only supports the teacher's presentation or explanation of course material by emulating a traditional classroom on the Internet. More interestingly, it also supports collaborative learning activities centered on students' exploration or application of the course material through VRLs. That is, students working in groups of two or more, mutually searching for understanding, solutions, or meanings.

We have evaluated our approach on a course of Experimental Techniques in Physics at the Spanish Open University (UNED), where students voluntarily performed lab assignments using VRLs. The results show (i) a correlation between the student exam grades and the number of completed lab assignments, (ii) that the collaborative feature we offer encourages student engagement (i.e., students that use the collaborative feature tend to complete more lab assignments), and (iii) that our synchronous collaboration approach helps to make the most of the lab assignments (i.e., students trained with collaborative labs get better exam results than those trained with non-collaborative labs).

Synchronous Collaborative VRLs

Moodle includes a good number of tools that provide asynchronous collaborative support (e.g., forums, the messaging system...). Our proposal takes advantage of such features by deploying VRLs into Moodle. In addition, we enrich Moodle collaborative support by providing a new feature: the synchronous collaboration among the VRLs that are included into a Moodle course. Our approach satisfies the following requirements:

1. **Supporting Deep Collaboration**. To the extent of our knowledge, existing proposals on synchronous collaborative VRLs limit collaboration to multimedia streams coming from the equipment server and from the users (Bochicchio & Longo, 2009). Thus, the only shared elements are audio, video and/or images. Under our approach, VRLs are deployed into Moodle, which has several plugins to provide synchronous sharing of audio, video and images (e.g., the Skype module available on http://docs.moodle.org/22/en/Skype_module). Therefore, our proposal supports such type of synchronous collaboration. In addition, our approach provides a higher collaboration level. For each participant in a collaborative session, there is a running instance of the shared VRL. The state of all the instances is synchronized, i.e., whenever a participant acts over its VRL instance, the changes produced on the VRL state are propagated to the remainder of the participants' VRL instances. For instance, Figure 1 shows a collaborative version of the "Three Tank" VRL (Dormido et al., 2008), which helps control engineering students to learn in a practical way many fundamental aspects of control processes. In the figure, two students work together to parametrize a Proportional-Integral-Derivative (PID) controller to get an overshoot and a settling time smaller than 20% and 1000s in Tank 1 and 15% and 500s in Tank 2, respectively. The areas in the Figure labeled "Virtual Lab" and "Remote Lab" visualize the lab state (i.e., the level of liquid in the tanks). Note that such state is the same for both students. Thus, although there are running two instances of the VRL, the students have the feeling of being working on the same VRL.
2. **Maximizing Software Reuse**. Building a VRL from scratch is too expensive, so it should be avoided "reinventing the wheel" every time a VRL requires collaborative support. Thanks to our approach, any existing VRL created with EJS is automatically converted into a collaborative lab by just clicking a single button. Thus, VRL developers can be focused on creative activities, avoiding the routine ones.
3. **Usability**. Our approach provides a high level of usability (i.e., the ease of use and learnability of a human-made object) for all the existing roles in the development, management and use of VRLs:
    a. The *VRL developer* creates VRLs by using EJS. Thanks to the EJS extension we have built, any VRL can be automatically converted into a collaborative lab by just clicking a single button.
    b. The *LMS administrator* deploys VRLs into Moodle, controls user access to the deployed labs, and performs maintenance activities related to the labs (e.g., VRL backup and restore). Such functionalities are graphically supported by our Moodle extension.
    c. The *teacher* and the *students* participate in collaborative sessions by using an adaptive visual interface. That is, to simplify the user interface and prevent errors, the interface dynamically changes to only make available the correct options for a given state of the collaborative session. For instance, a student visualizes the "participate as an invited student" button (Figure 3.a) only when s/he has been previously invited to a collaborative session.
4. **Scalability**. Our approach is highly scalable, i.e., many collaborative sessions may be running at the same time. We have adopted a peer-to-peer (P2P) approach which avoids that multiple collaborative sessions overload the server that host the Moodle portal and the VRLs. When a collaborative session begins, users just interact with the server by downloading the applet that implements the VRL they are going to use in the session. Then, an instance of the applet is locally run in each participant's computer. The instances communicate each other through a server-less collaboration over TCP and UDP protocols. Thus, the communication between the server and the participants' computers is limited to simple messages of session creation, session pause, session close, etc.

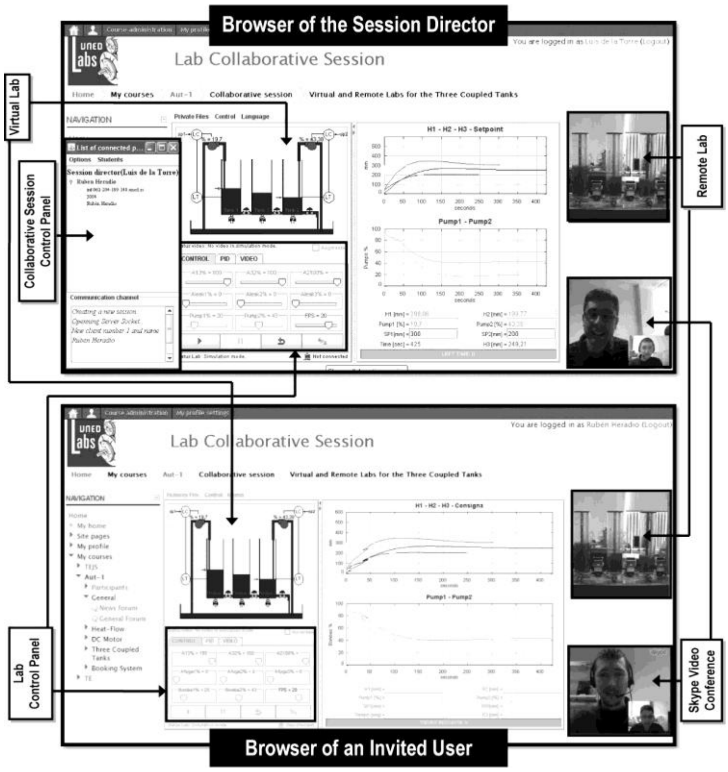


Figure 1. Example of Two Users participating in a Collaborative Experimental Session.

A fundamental issue in a synchronous collaborative system is the *Floor Control* (Dommel & Garcia-Luna, 1997). This term points out how the system components share the computational resources. Our proposal tries to offer shared VRLs that can be controlled in real-time by the different members of a virtual class. In our case, the shared VRL is composed of a Java applet generated with EJS. There are two main kinds of components to coordinate: one *session director*'s applet and some *invited user*'s applets. The session director is responsible for starting, monitoring and closing a collaborative session. Thanks to the Moodle and EJS extensions we have developed, the session director's applet manages in real-time the virtual class and synchronizes all the invited user's applets. S/he has a list of invited users connected to the virtual session and can disconnect any invited user's at any moment. In order to have a suitable floor control, connected invited user's applets are locked and they cannot interact with the shared VRL in a first moment. They are only allowed to see in real-time what the session director is doing in the shared application. This way, the collaborative session avoids collisions of events which can cause unwanted and incoherent results. One example of this problem could be that the real equipment which controls the VRL becomes uncontrollable because of unsuitable user interactions.

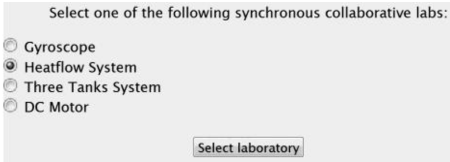
Extending Moodle

In the following lines, the behavior of the *EJSApp Collab Session* block, which extends Moodle to support synchronous collaborative sessions of VRLs, is illustrated:

1. **From the session director point of view**, a collaborative session is composed of the following steps:
    a. A session is created by clicking the button "Create collaborative session" (Figure 2.a).
    b. The session director selects then the potential participants to the session he is creating (Figure 2.c). Selected participants are *potential* in the sense that they may or may not decide to participate into the session. When the "Invite participants" button is clicked, they will be notified with an e-mail and a Moodle internal message.
    c. The VRL is accessed in collaborative mode, i.e., the session director's applet manages the virtual class and synchronizes all the invited user's applets.
    d. The collaborative session is finished by clicking the "Close collaborative session" (Figure 2.d).
2. **From an invited user point of view**, a collaborative session is composed of the following steps:
    a. Once invited, the user clicks on the button "Participate as an invited student" (Figure 3.a). To prevent misuses of EJSApp Collab Session, its graphical interface changes to show just the valid choices available to a given situation (see Figures 2.a, 2.d and 3.a). So, the "Participate as an invited student" button is only visible because the user has been invited to, at least, one collaborative session.

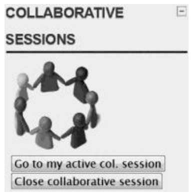
b. From all the received invitations, the user selects in which session s/he wants to participate (Figure 3.b). Note that a course member can be invited to several collaborative sessions, but s/he can only participate in one of them at the same time.
c. The VRL is accessed in collaborative mode.
d. The user stops participating in the session when (i) s/he decides to leave it or (ii) when the session director closes it. In the former case, the user is free to enroll either to that session again or to any of the other current available invitations.

(a) Starting a Synchronous Collaborative Session.



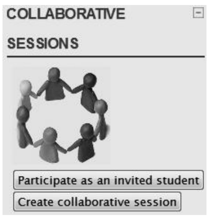
(b) Selecting the Collaborative VRL to be used within the Session.

(c) Selecting the Session Participants.



(d) Closing a Collaborative Session.

Figure 2. Synchronous Collaborative Session in Moodle from the Session Director Point of View.



(a) Accepting an Invitation to a Collaborative Session.

(b) Selecting one of the Available Invitations.

Figure 3. Synchronous Collaborative Session in Moodle from an Invited User Point of View.

Extending EJS

We have extended EJS to add synchronous collaborative support to any VRL developed with this tool. The last EJS release, its version 4.3.7, includes the collaborative approach described in this paper. This is done by *TCP* and *UDP* connections that periodically share and synchronize the VRL state of the session director with the VRLs of the invited users. The extension provides the session director, as an additional feature related to the synchronous collaboration, with the “Collaborative Session Control Panel” shown in Figure 1. This panel includes a list of the invited users connected to the collaborative session (e.g., control panel in Figure 1 shows that “Luis de la Torre” is the session director and “Ruben Heradio” is an invited user). Using such list, the session director can perform the following tasks:

1. Supervising which users have already connected to the collaborative session in order to call the roll before starting the experimentation.
2. Disconnecting any invited user at any moment.
3. Assigning the *chalk* to an invited user. With this feature, the session director gives permission to control the shared VRL to a specific invited user, by selecting him from the list. The chalk enables a student to manage the VRL, but not the collaborative session (i.e. the control panel is always commanded by the session director).

Figure 4 depicts the communication framework that underlays the collaborative sessions. When a session begins, users just interact with the Moodle server by downloading the applet that implements the VRL they are going to use in that session (see dashed lines in Figure 4). On the other hand, users participating in a session interact each other through a server-less collaboration over TCP and UDP protocols (see solid lines in Figure 4). Thus, the communication framework we propose supports multiple simultaneous sessions without overloading the Moodle server.

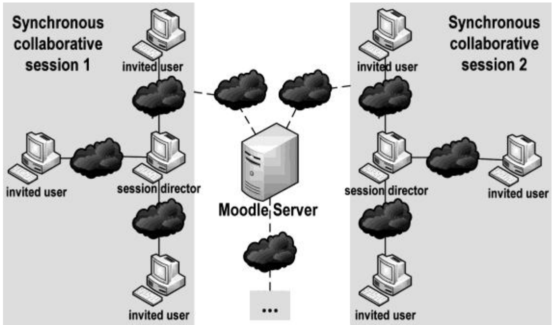


Figure 4. A Network of Collaborative Sessions

Invited users' applets are connected directly to the session director's applet in a P2P centralized overlay network. In contrast with server-based approaches, our e-learning system is focused in a server-less architecture. This communication method avoids delays caused by the server processing in the data flow because the communication engine is embedded in the Java applets downloaded by the users. In addition, the number of network connections can be substantially decreased because the session director's applet can manage the session, the floor control, and the data exchange having higher control over the invited user applets. As stated, the P2P network is centralized around the session director's applet. This last application is the central node of the collaborative class and contains a multithread communication module which manages the synchronization of all the applets that compose the shared VRL. Invited users' applets are connected to the central node over TCP and UDP sockets performing a centralized network.

To synchronize in real-time all the applets connected to the virtual class, a method based in Java object tokens (Dommel & Garcia-Luna, 1997) is used. Java object tokens are small update messages which contain a String object that defines the action to be performed by other applets of the same session. The small amount of sent information optimizes the network use and reduces the connection delay.

Since all the applets must be in the same state at any time, it is necessary to synchronize them. The developed communication framework provides a transport service suitable for all update data: a TCP-based channel for reliable messages and a UDP-based channel for fast messages. The TCP channel is used to update all the variables of the application because the transmission of the values needs the reliability of an ACK-based protocol. The UDP channel is used to transmit the small changes in the user-interface and this requires to be quickly updated in the rest of the applets.

Experimental Evaluation

In terms of number of students, the Spanish Open University (UNED), with more than 260,000 scholars, is the biggest university of Spain and the second one of Europe, next to the English Open University. To support their students, UNED is composed of a network of associated learning centers scattered around the world (more than 60 centers distributed across Spain, Europe, America and Africa). Unfortunately, the geographical dispersion of the students makes impossible to provide the scientific courses of UNED with traditional labs at a reasonable cost. Since the nineties, the Department of Computer Science and Automatic Control of UNED has been very concerned about this problem and has been working in new ways to illustrate scientific phenomena that require costly or difficult-to-assemble equipment. The UNEDLabs web portal (http://unedlabs.dia.uned.es) is the fruit borne by such work. It hosts a rich network of VRLs for students of UNED and other Spanish Universities, such as the Leon University and the Almeria University. All VRLs in UNEDLabs have been developed using the approach described in this paper. This section reports the experimental evaluation of our work on a course of *Experimental Techniques in Physics* supported by UNEDLabs.

Participants

The experimental evaluation of our approach was performed on two consecutive academic courses of *Experimental Techniques in Physics* at UNED: 2010-11 and 2011-12. In both years, students were encouraged to carry out five voluntary lab assignments supported by the following VRLs:

1. A motorized rotatory laser to illustrate the Snell's law (de la Torre et al., 2011).
2. A motorized optical bench to estimate the focal of thin lenses.

3. A Hooke's law simulator (de la Torre et al., 2011).
4. A Geiger counter based VRL to experiment with radioactive disintegration laws.
5. An RC Circuit.

Whereas the 2010-11 course had 53 students and the lab assignments were individual (i.e., no collaborative support was available), the 2011-12 course had 62 students and the assignments were performed in groups of two/three students by using the collaborative features described in this paper. Table 1 and Figure 5 describe the dataset of our experimental evaluation, which is composed of the number of lab assignments completed by the students and their grades on the course final exam (note that exam grades are rated on a 10-point scale).

Table 1: Dataset Descriptive Statistics.

		Mean	Standard Deviation	Median	Skew	Kurtosis
Course 2010-11	Exam Grades	3.91	2.50	3.00	0.56	-0.52
	Number of Completed Lab Assignments	1.53	1.75	1.00	0.92	-0.53
Course 2011-12	Exam Grades	5.40	2.98	6.00	-0.04	-1.49
	Number of Completed Lab Assignments	2.79	2.10	3.00	-0.19	-1.65

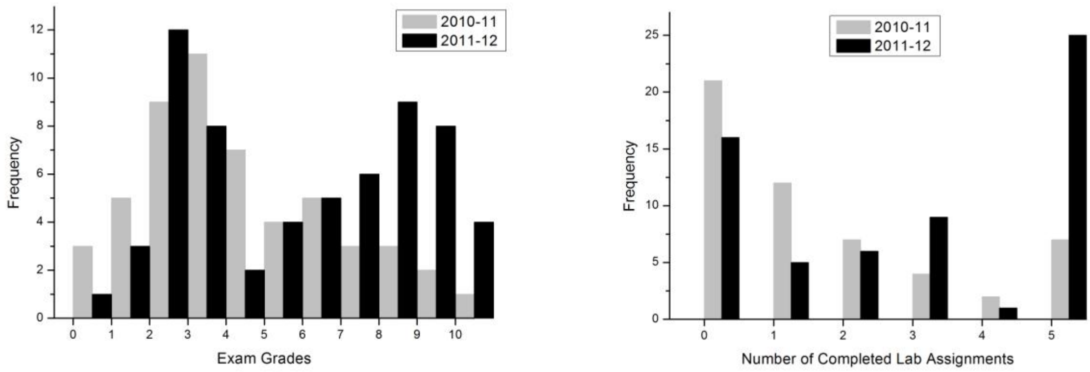


Figure 5. Dataset Histograms.

Results

The Exam Grades and the Number of Completed Lab Assignments are Correlated

The scatter plot in Figure 6 depicts the relationship between the number of completed lab assignments and the exam grades for both courses. Since there are many data points (53+62=115) and significant overlap among them, points have been grouped into colored hexagonal cells. The color range goes from light grey (one single point) to black (when a cell groups 16 points). In addition, Figure 6 includes the linear regression lines of (i) the courses 2010-11 and 2011-12 separately, which just take into consideration their corresponding 53 and 62 points, respectively; and (ii) both courses jointly. Table 2 summarizes the correlation tests of the relation between assignments and exam grades. Since the *p*-values are minor than 0.01, the tests show that the correlation is statistically highly significant.

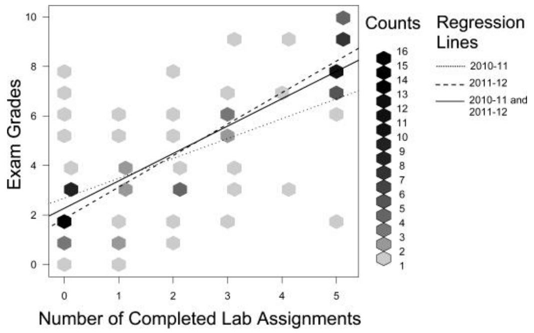


Figure 6. Scatter Plot and Regression Lines for the Dataset.

Table 2: Correlation and Regression Lines between Exam Grades and Completed Lab Assignments.

Courses	Pearson's product-moment correlation			Regression Line Grade = B_0 + B_1*NumberOfAssignments	
	Correlation factor *r*	t	*p*-value	B_0	B_1
2010-11	0.561544	4.8465	1.22e-05	2.6804	0.8017
2011-12	0.8941395	15.467	< 2.2e-16	1.854	1.272
2010-11 and 2011-12	0.7877397	13.593	< 2.2e-16	2.271	1.105

Collaborative Labs encourage Student Engagement

Table 1 shows that students who performed the lab practices in a collaborative fashion completed on average more assignments than the ones who made it individually (i.e., whereas the mean and the median for 2010-11 are 1.53 and 1 respectively, for 2011-12 are 2.79 and 3). *Student's t-test* of the number of completed assignments for 2010-11 and 2010-12 has $t = 3.4684$ and *p*-value = 0.0007417. So, the difference between using our collaborative approach and not using it is statistically highly significant. In addition, the *Cohen's d* is 0.6465427. Therefore, the difference effect size is moderate (>0.5).

Synchronous Collaboration increases Lab Assignment Performance

As Table 2 shows, the correlation factor for course 2011-12 is higher than for 2010-11 (0.89>0.56), and the slope of the 2011-12 regression line is steeper than the 2010-11 one (1.28>2.69). So it looks like students get better exam results when practicing with collaborative labs or, in statistical terms, it seems that the collaborative support *moderates* the effect that the number of lab assignments has over the exam grades (Jaccard & Turrisi, 2003). To check such moderation effect, the two multiple regression models summarized in Table 3 has been used. Whereas, Model 1 just includes variables *NumberOfAssignments* and *HasTheCollaborativeFeature* to explain the exam grades, Model 2 includes the moderation effect encoded by the product *NumberOfAssignments* * *HasTheCollaborativeFeature* as well. To facilitate the interpretation of both models:

1. *NumberOfAssignments* is put in *deviation form*, i.e., every value x is centered to the mean: $x_{centered}=x-mean_{NumberOfAssignments}$. Thus, the regression coefficient B_1 is 0 when *NumberOfAssignments* is equal to its mean.
2. *HasTheCollaborativeFeature* is encoded as (i) 1 for collaborative assignments, and (ii) 0 for non-collaborative ones.

Table 3: Moderation Effect Evaluation by using Multiple Regression Models.

Moderation effect?		**Coefficient values**	**Coefficient *p*-values**	R^2
No: Model 1 **Grade = B_0 + B_1*NumberOfAssignments + B_2*HasTheCollaborativeFeature**	B_0	3.90566	< 2e-16	0.6209
	B_1	1.09685	< 2e-16	
	B_2	1.49757	1.62e-05	
Yes: Model 2 **Grade = B_0 + B_1*NumberOfAssignments + B_2*HasTheCollaborativeFeature + B_3*NumberOfAssignments*HasTheCollaborativeFeature**	B_0	3.9057	< 2e-16	0.6446
	B_1	0.8017	4.87e-08	
	B_2	1.4976	9.78e-06	
	B_3	0.4703	0.00754	

Hence, the interpretation of the regression coefficients for Model 2 is:

- The estimated grade for a student that has completed the average number of lab assignments without using the collaborative feature is B_0=3.9057.
- The average return per lab assignment completed without using the collaborative feature is B_1=0.8017.
- The difference in grade between completing the average number of lab assignments using the collaborative feature and not using it is B_2=1.4976.
- The difference in the grade by completed assignments slope between non-collaborative and collaborative labs is B_3=0.4703.

The following points support the existence of a statistically significant moderation effect:

1. Comparing both models, the *NumberOfAssignments* coefficient B_1 decreases, i.e., it becomes less important when the interaction *NumberOfAssignments***HasTheCollaborativeFeature* is considered. Besides, in Model 2 the moderation effect coefficient B_3 has *p*-value 0.00754, i.e., the interaction term is statistically highly significant.
2. Whereas Model 1 explains 62% of the variance in the exam grades, Model 2 explains 64% of the variance (i.e., R^2 is 0.6209 and 0.6446 for Models 1 and 2, respectively).
3. ANOVA model comparison for both models has F=7.4083 and Pr(>F)=0.00754, i.e., it is statistically highly significant that Model 2 estimates the exam results better than Model 1.

Discussion and Concluding Remarks

To the extent of our knowledge, previous works on synchronous collaborative support for VRLs are limited to the usage of communication tools such as chat or video-conference applications (Tsovaltzi et al, 2010; Bochicchio & Longo, 2009; van Joolingen et al., 2005). Our approach not only provides that kind of collaboration but also a new way of communication, based on the VRL itself. For each participant in a collaborative session, there is an instance of the shared VRL running. The states of all the VRL instances are synchronized, i.e., whenever a participant acts over its VRL instance, the changes produced on the VRL state are reflected in the other participants' VRL instances. This way, participants have the feeling of working together on the same VRL.

Gravier et al. (Gravier et al., 2008) have surveyed forty-two different remote labs finding that every project implements its own software architecture with no reuse. Both building a VRL from scratch and creating its collaborative support requires a huge effort. Our work alleviates such effort since EJS is a code generator that speeds up the VRL development, and our approach automatizes the addition of collaborative support to existing EJS VRLs. Thus, we avoid "reinventing the wheel" every time a VRL requires collaborative features.

Finally, there is experimental evidence of the usefulness of our work. In particular, the statistical analysis reported in this paper shows (i) a correlation between the student exam grades and the number of completed lab assignments, (ii) an increase in student engagement thanks to the collaborative feature we propose, and (iii) a moderation effect of our synchronous collaboration approach and the number of completed lab assignments. Given the success of this pilot project, we plan to extend the use of our collaborative approach to other UNED courses with a major number of students.

References

Bafoustou G., & Mentzas, G. (2002). Review and functional classification of collaborative systems. *International Journal on Information Management*, 22, 281-305.

Bochicchio, M., & Longo, A. (2009). Hands-on remote labs: Collaborative web labs as a case study for it engineering classes. *IEEE Trans. on Learning Tech*., 2(4), 320-330.

Boulos, M., Taylor, A. & Breton, A. (2005). A synchronous communication experiment within an online distance learning program: A case study. *Telemedicine journal and e–health*, 11(5). 583-593.

Chang, G.W., Yeh, Z.M., Chang, H.M., & Pan S.Y. (2005). Teaching photonics lab using remote-control web technologies. *IEEE Transactions on Education*, 48(4), 642 - 651.

Christian, W., & Esquembre, F. (2007). Modeling physics with easy java simulations. *The Physics Teacher*, 45. 475-480.

Christian, W., Esquembre, F. & Barbato, L. (2001). Open source physics. Science, 334(6059). 1077-1078.

Dommel, H.P., & Garcia-Luna, J.J. (1997). Floor control for multimedia conferencing and collaboration. *Multimedia Systems,* 5, 23-38.

Dormido, R., Vargas, H., Duro, N., Sanchez, J., Dormido-Canto, S., Farias, G., Esquembre, F., & Dormido, S. (2008). Development of a web-based control lab for automation technicians: The three-tank system. *IEEE Trans. on Education*, 51(1), 35-44.

Ellis, K. (2009). Field guide to learning management systems. Technical report, ASTD Learning Circuits.

Gravier, C., Fayolle, J., Bayard, B. Ates, M. & Lardon, J. (2008) State of the art about remote labs paradigms - Foundations of ongoing mutations. *International Journal of Online Engineering*, 4(1).

Guimaraes, E., Cardozo, E., Moraes, D., & Coelho, P. (2011). Design and implementation issues for modern remote labs. *IEEE Trans. on Learning Tech.*, 4(2), 149-161.

Heradio, R., de la Torre, L., Sanchez, J., Dormido, S. & Vargas, H. (2011) An architecture for virtual and remote labs to support distance learning. *Research in Engineering Education Symposium, Madrid, Spain*.

Jaccard, J.J., Turrisi, R. (2003). Interaction Effects in Multiple Regression. *SAGE Publications, Series: Quantitative Applications in the Social Sciences*.

van Joolingen, W.R., de Jong, T., Lazonder, A.W., Savelsbergh, E.R., & Manlove, S. (2005). Co-lab: research and development of an online learning environment for collaborative scientific discovery learning. *Computers in Human Behavior*, 21. 671-688.

Kozma, R. (1994). Will media influence learning? Reframing the debate. *Education Technology Research and Development*, 42(2), 7-19.

Ma, J., & Nickerson, J.V. (2006) Hands-on, simulated, and remote labs: A comparative literature review. *ACM Computing Surveys*, 38(3).

Marjanovic, O. (1999). Learning and teaching in a synchronous collaborative environment. *Journal of Computer Assisted Learning.* 15. 129-138.

de la Torre, L. Sanchez, J., Dormido, S., Sanchez, J.P., Yuste, M., and Carreras, C. (2001). Two web-based labs of the fisl@bs network: Hooke's and Snell's laws. *European Journal of Physics*, 32(2), 571-584.

Tsovaltzi, D., Rummel, N., McLaren, B.M., Pinkwart, N., Scheuer, O., Harrer, A., & Braun, I. (2010). Extending a virtual chemistry lab with a collaboration script to promote conceptual learning. *International Journal of Technology Enhanced Learning*, 2. 91-110.

Wannous, M., & H. Nakano, H. (2010). Nvlab, a networking virtual web-based lab that implements virtualization and virtual network computing tech. *IEEE Trans. on Learning Tech.,* 3(2). 129-138.

CSCL 2013

Computer Supported Collaborative Learning

June 15–19, 2013

University of Wisconsin – Madison

To see the world *and* a grain of sand:
Learning across levels of space, time and scale

Conference Proceedings Volume I

Full Papers & Symposia

Editors: Nikol Rummel, Manu Kapur, Mitchell Nathan, Sadhana Puntambekar

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To See the World and a Grain of Sand: Learning across Levels of Space, Time, and Scale. Proceedings of the International CSCL Conference 2013

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The 10th International Conference on Computer-Supported Collaborative Learning (CSCL) is to be held at the University of Wisconsin-Madison, USA, from June 15 through 19, 2013 (http://www.isls.org/cscl2013/).

The CSCL conference is a multidisciplinary, international meeting sponsored by the International Society for the Learning Sciences (ISLS). The conference is held biennially in the years alternating with the International Conference of the Learning Sciences (ICLS). So far the conference has been held in the USA, Europe, and Asia. This conference is an important venue for CSCL researchers to come together from around the world to meet, report recent research findings and discuss timely and important issues of interest to the community. It draws researchers from psychology (educational, social, developmental, cognitive, linguistic, cultural-historical), the social sciences (anthropology, sociology, communication studies, philosophy of language), and design disciplines (computer and information science, curriculum and didactics), as well as researchers from Artificial Intelligence (AI) and the cognitive sciences.

CSCL interactions in both online and face-to-face contexts occur at multiple levels of time, space, scales of analysis, and scales of group/population structure, to name a few. The title of our conference theme, inspired by (and modified from) William Blake's poem "Auguries of Innocence" reflects this unique aspect of CSCL in which interactions and learning need to be understood, supported and analyzed at multiple levels. We see an attention to the theoretical, methodological and technological issues of addressing research at multiple levels to be one that is highly responsive to current research among the CSCL community as well as developing emerging epistemological and methodological issues that will shape our intellectual efforts well into the future.

The relevance and timeliness of the conference theme is evidenced by workshops and presentations at previous ISLS conferences and by recent publications in relevant journals. For instance, the issue of *analyzing* CSCL interactions at multiple levels and with various methodological approaches, in order to further our understanding of the learning mechanism underlying CSCL, has received a lot of attention in the community over the last decade. At ICLS 2004 Nikol Rummel and Hans Spada organized a symposium entitled "Cracking the Nut – But Which Nutcracker to Use? Diversity in Approaches to Analyzing Collaborative Processes in Technology-Supported Settings." At ICLS 2008, Daniel D. Suthers, Nancy Law, Carolyn P. Rose, Nathan Dwyer held a workshop with the title "Developing a Common Conceptual and Representational Framework for CSCL Interaction Analysis", which was followed by a series of workshops at the recent CSCL and ICLS conferences and culminated in an edited book to appear in June 2013 at Springer: Suthers, D., Lund, K., Rose, C. P., Teplovs, C., & Law, N. (in press). Productive Multivocality in the Analysis of Group Interactions. Furthermore, in his introduction to the most recent issue of the International Journal of Computer-Supported Collaborative Learning (ijCSCL, Volume 8, Issue 1), which is dedicated to the topic of "Learning across levels", editor-in-chief Gerry Stahl cites and takes up the CSCL 2013 conference theme to argue that "time has come for CSCL to address the problem of traversing levels of analysis with exacting research" (p. 10).

At CSCL 2013, the conference theme is addressed from different perspectives through three keynote talks by Josep Call (Max Planck Institute for Evolutionary Anthroplogy, Leizpig, Germany), Kori Inkpenn Quinn (Microsoft Research, USA), and Justine Cassell (Carnegie Mellon University, Pittsburgh, USA). The conference theme will further be showcased by an invited plenary session on "Multiple methods in CSCL research", and by various pre-conference workshops and multiple contributions (paper and poster sessions, submitted and invited symposia, panels, and demonstrations of innovative educational technology) throughout the main conference.

We received many high-quality submissions for CSCL 2013. Submissions categories included full papers (8 pages, presenting mature work), short papers (4 pages, summarizing work that is still in progress or of smaller scale) and posters (2 pages, sketching work in early stages or novel and promising ideas). Further submission categories were symposia (8 pages, conveying larger ideas or integrating findings around a specific issue), panels (3 pages, coordinating multiple perspectives on a specific, timely topic), demonstrations (3 pages, providing an opportunity to interactively present new tools and technologies for supporting and/or analyzing collaborative learning), and pre-conference workshops and tutorials (5 pages, proposing collaborative knowledge-building sessions where participants actively work together on a focused issue). Submissions were also invited for a doctoral consortium and an early career workshop.

Each full paper, short paper, or poster proposal was reviewed blind by one or two peer reviewers and one program committee member. Program committee members then summarized the reviews and provided the program co-chairs with a brief assessment. Finally, the program chairs carefully considered the reviews and the meta-review, and in many cases read the submissions themselves before making the final decision. Proposals for symposia and panels were reviewed by two program committee members and by the program co-chairs. Demonstration, workshop and tutorial proposals were reviewed by members of the respective steering committee within the CSCL 2013 organization.

As in previous years, the acceptance rates for full and short papers were competitive: The acceptance rates for full papers and short papers were 36% and 39% respectively. For posters, the acceptance rate was more inclusive (78%) to allow for presentation of work that is in early stages and for productive discussions of novel and promising ideas.

The CSCL 2013 proceedings comprise two volumes: Volume 1 includes full papers and symposia. Volume 2 includes short papers, posters, and panels, demonstrations, as well as abstracts for all community events (keynotes, workshops and tutorials, early career and doctoral workshops, and invited panels and symposia).

Many fields within the physical and social sciences and the design sciences have long grappled with the notion of *supervenience* -- how phenomena at one scale of time or space can influence and be influenced by those at larger and smaller scales. New technologies and methodologies are making theoretical advancements possible, and leading the exciting and growing field of CSCL into frontiers of research and development that stand to contribute to improvements in education, the design of new means for collaborating, and new end-user experiences. Our world is becoming a more connected place because of the ways -- both large and small -- that we interact with technologies, and in so doing, come to interact with one another. As organizers of this conference and editors of this volume, we hope these interactions continue well beyond the bounds of this event or these proceedings, but continue to reshape ourselves and the world.

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