#03

Medina, J.L. (2013). Self-regulation and time factor in virtual and remote laboratories. *eLC Research Paper Series, 7, 27-38.*

# SELF-REGULATION AND TIME FACTOR IN VIRTUAL AND REMOTE LABORATORIES

José Luis Medina

eLearn Center. Universitat Oberta de Catalunya
jmedinag@uoc.edu

## Self-regulation and time factor in virtual and remote laboratories



## ABSTRACT

In the field of practical development of competences in scientific and engineering studies, the emergence of distance learning programs in these disciplines, as well as the rapid development of ICT, has allowed the evolution of classical laboratories towards a new typology of laboratories: the commonly called **virtual labs**, focused on the development of simulation-based practices in both classroom or remote sessions and **remote laboratories** equipped with real equipment that are connected and accessible remotely, by providing the student a practical resource not defined in a specific space and time such as onsite laboratories.

Currently extensive information on the different types of laboratories can be found; their structure, the tools that they use, the type of experiment performed, but there is less information about teaching and pedagogical application of these technologies. Factors like self-regulation, allowing a constructivist approach to training with these tools; the Time factor and assessment are subjects susceptible to be studied.

Starting from the generic structure of remote laboratory, exposed in the first section, we will study how this structure can influence the factors under study: self-regulation and Time Factor, and how to approach this structure and the elements that make it up to improve these aspects.

## KEYWORDS:

Remote laboratories, self-regulation, Time factor

Medina, J.L. (2013). Self-regulation and time
factor in virtual and remote laboratories.
*eLC Research Paper Series, 7, 27-38.*



# INTRODUCTION

Traditionally, in technical or scientific disciplines, a separation between theoretical and practical sessions has always been clear. The theoretical sessions are developed through lectures or materials supplied to the student by the instructor and the practical sessions are developed in laboratories, where the student implements the theoretical knowledge received, usually through guided practices sessions focused to solve a problem o project. In these disciplines, the emergence of distance learning programs has caused the evolution of classical laboratories. This new structure has had a clear separation into two distinct types: the called virtual labs (VL), focused on the development of simulation-based practices and remote laboratories (RL) based on real equipment that are connected and accessible remotely, by providing the student a practical resource not defined in a specific space and time. It is becoming an attractive and economical solution for developing and sharing practical environments with a high cost equipment.

In the last decade and especially the last few years, have been developed and implemented a large number of remote laboratories in many institutions of higher education and publications concerning several aspects have appeared (García-Zubía, Díaz Labrador, Jacob Taquet & Canivell, 2008) in terms of its advantages and disadvantages (Luís & García-Zubía, 2007), the different architectures and designs (Gobbo & Vaccari, 2005), technologies for implementation (Indrusiak, Glesner & Reis, 2007) or applied teaching (Ma & Nickerson, 2006).

Furthermore, the development of open source Web applications enabling the management of content and users for virtual environments, also called Learning Management Systems (LMS), allows the use of conducive and constructive methodologies, where the process of student learning (Reeves, Herrington & Oliver, 2004) is conducted through collaboration, cooperation and participation in discussion forums, construction and development work collaboratively.

These two technologies, the remote labs and LMS, have often worked together, because one complements the other. The integration of practical resources in distance learning environments, either through activities that students can perform at home using materials provided or by accessing remote resources available to the institution within the theoretical material, is becoming a natural way of acquiring knowledge. It is also, a methodological change in the way of teaching/learning that deserves study. The flexibility of remote environments must enable students to acquire the practical skills by adapting the content to their specific learning needs, at their own pace and progress in terms of content, without diminishing the quality of the content taught.

Pedagogical factors as self-regulation, allowing a constructivist approach; or the Time factor are the scope of this work. Starting from the generic structure of remote laboratory, exposed in the next section, we will study how this structure can influence the elements under study and how this structure and the elements that make it up can improve these aspects.

# GENERIC STRUCTURE OF REMOTE LABORATORIES: FACTORS THAT DETERMINE THE SELF-REGULATIONS AND TIME FACTOR

The factors that determine the pedagogical appliances of the remote laboratories are connected both in teaching strategies and hardware-software infrastructure. The generic structure for both RL and VL has as terminal aim conducting remote experiments and practical experiences so that students acquire practical skills (Fig. 1). The architecture must support the laboratory, but it also requires other resources such as its configuration, equipment configuration, reserve management, access control, possibility of collaborative work or integration with the theoretical subjects that have to be taken into account when designing the entire infrastructure supporting laboratories.

The final element of the whole structure of this kind of laboratories is based on processes or systems that the student could find both in real work environments but also here with a clear pedagogical function. The physical (RL) or virtual process (VL) is the purpose why the structure is designed and it is the primary focus of the experience or project to be developed by the student.

Closely connected with the process there is the equipment or software that performs the control functions. The control device is variable depending on the objectives for which the laboratory has been designed: microcontroller-based systems, Programmable Logic Controllers (PLC), robot controllers or computers and equipment generally targeted to a specific scientific or technical discipline. These devices have the function of performing the, pOrocess.

The typology of the experiment and its controller are the elements that have a wide variation. In studies developed in the last years (Gravier, Fayolle, Bayard, Ates & Lardon, 2008) (MA & Nickerson, 2006), a great number of laboratories dedicated to teaching electronics, ICT, automatic, multidisciplinary physical has been found while a low number to other subject areas such as chemistry, hydraulics, mechatronics or astronomy.

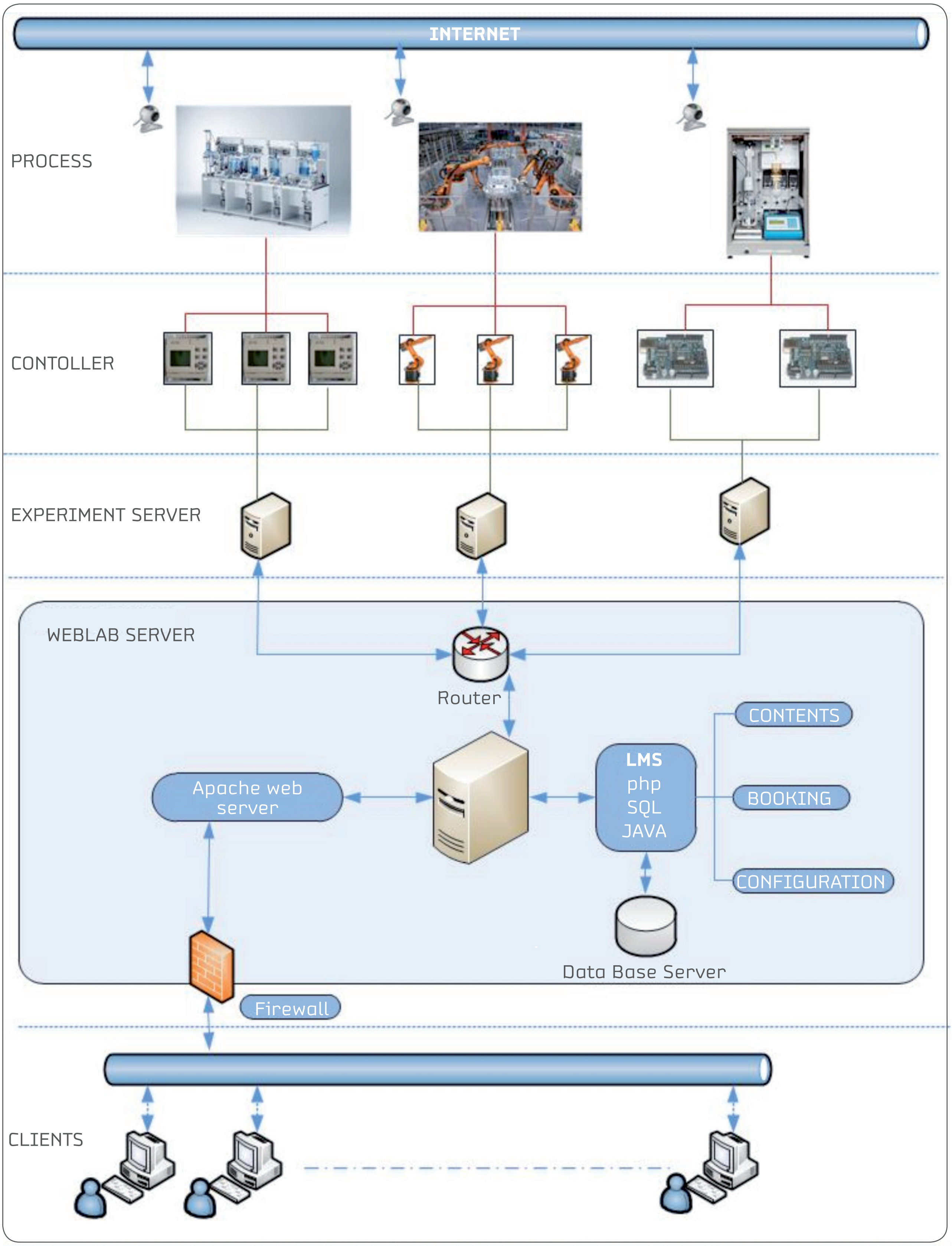
The other elements that make up the structure are focused on managing the work from the different users:

- The whole system manager or administrator, who has the task of maintaining the overall structure of the laboratory in terms of hardware, software and connectivity.
- The profile of the teacher, who has to program and control the teaching-learning process, opening or closing the access to resources, determining the time required for execution, sequencing and evaluating experiences of the work done by the student. The student finally has access to the laboratory by means of the booking application, accessing and interacting with the process through a graphical interface generally located in the server of the experiment.
- The student as a subject around whom the design and implementation of these tools. The student must have enough information to run applications as well as handling and feedback of results.

Most equipment and tools that comprise the rest of the structure are within the scope of ICT. As shown in Figure 1, the element connected to one or more control system is the **laboratory or experiment server**, usually a computer that has several roles:

- The **experiment manager**, developing operations of input and output information to and from the experiment.
- The server must have the **tools to perform the experiment by programming or control the device** (Awkash & Srivastava, 2007). These tools are normally proprietary and generally belonging to manufacturers like Matlab (Mathworks, 2013) or Labview (Instruments, 2013) (Gravier, Fayolle, Bayard, Ates & Lardon, 2008). Others tools are also found in this particular field, used to design applications with specific programming languages associated to the controlled devices.
- The server must give **external access to the network** for the process and the tools to control it. The technologies applied in this

**Figure 1.** Generic RL structure.



part, are normally programming languages such as Java and Java applets, dynamic web pages, programming languages (XML, C + +, etc.) or connections VNC in order to connect the computer remotely (Gravier, Fayolle, Bayard, Ates & Lardon, 2008).

The management of different server's experiments, located in the same geographical area or geographically distributed in different institutions, should be centralized in the **WebLab Server** that provides two functions: **the management of resources** and access to **experiment managers**.

It will be generally a computer with a network operating system that incorporates user management tools and web services. A widespread typology is performed with Linux operating system, Apache as web server, MySQL databases and PHP programming language, without discarding other tools that are also used, following in a greater or lesser degree this philosophy LAMP (Linux + Apache + MySQL + PHP). This computer should be responsible for authentication, schedule and management of all the experiments; also it must centralize the records of the student work and the access security (Awkash & Srivastava, 2007).

The function of the weblab server is the control of the Laboratory, but it must have a close relationship with the LMS that integrate the courses. Small departments or institutions could have in the same equipment the LMS and the Weblab server, but normally two different equipments assume these two functions, and a module integrated in the LMS has the functions to linking the LMS with the laboratory. The LMS allows creating a web interface between the user and the laboratory not depending on the type of computer and operating system, increasing its versatility and functionality. The web environment must integrate the screens and services that allow laboratory management of different users.

## FACTORS AFFECTING SELF-REGULATION IN REMOTE LABORATORIES

The student retention and completion rates in distance learning have been investigated extensively (Berge & Huang, 2004). One of the variables that can help to solve low rates of completion in e-learning studies is applying self-regulatory strategies, redefining the role of the instructor as support of the student in his self-regulated and independent knowledge through the use web tools (Dabbagh & Kitsantas, 2004). So the remote laboratory, as a tool, must be an important factor that helps students achieve their goals by improving their results and reducing abandonment.

The self-regulation as an important factor in a constructivist e-learning educational system can be defined as the skills required for students to understand and control their learning environment. The student must set goals, select strategies to achieve the goals, implementing and monitoring their progress toward goals (Schunk, 1996). Self-regulation is very important in the learning process because students with better self-regulation skills learn with less effort and get better academic results (Pintrich, 2000; Zimmerman, 2000).

Three elements are decisive in defining the profile of self-regulation that could have a student (Gregory Schraw, Hartley & Hartley, 2006):

1. **Cognition**, defined as the skills necessary to encode, memorize and retrieve information, includes three types of skills:
   a. **Cognitive strategies** used by both the student and the teacher to enhance learning (graphs, charts, summaries, mind maps).
   b. **Problem-solving strategies**, such as predict-observe-explain: POE (Rickey

& Stacy, 2000) frequently used in laboratories.

c. **Critical thinking** for the analysis of the results and consistency.

2. **Metacognition** defined as the skills that enable students to understand and control their cognitive processes The two subcomponents define this parameter (Rickey & Stacy, 2000):
   a. **Knowledge of cognition**, based on the self-recognition of skills available to the student (**declarative knowledge**), knowledge and application of strategies and procedures (**procedural knowledge**) and how and when to use these strategies (**conditional knowledge**).
   b. **Regulation of cognition** that includes planning, monitoring and self-evaluation of the whole learning process.

3. **Motivation** defined as beliefs and attitudes that affect student use and development of cognitive and metacognitive skills:
   a. **Self-efficacy** refers to the degree to which an individual is sure to perform a task.
   b. **Epistemology.** In general, there is a growing consensus that students and teachers disagree on epistemological world views. The point of view of students and teachers are different, this problem difficult the degree of transmission and affects student motivation in problem solving or practical experience (Roth & Tobin, 2001; Schraw & Olafson, 2002; Tsai, 2001)

Autoregulation processes are determined by the combination of three factors simultaneously, the arrangement of one of them independently is insufficient and it is the combination of the three factors which determine an improvement in educational results.

In the area of cognition, the use of remote labs is to be treated as a tool that will enable the development of students' cognitive skills. To develop these skills, the first step to a correct use in this type of laboratory is marking the objectives to be met within the learning process, highlighting factors such as (Bauer, Fedak, Hajek & Lampropoulos, 2008):

- Understanding the structured design and methodology to be applied to solve the application
- Analyze the system in a structured way by dividing complex systems into subsystems.
- Understand the differences between simulations and real processes
- Enabling the student to select the right equipment in every situation to perform the tasks or programs of a real process.

In accordance with the cognitive skills and the objectives established by the remote laboratory the learning methodology that would achieve those objectives must be defined (Rojko, Hercog & Jezemik, 2009) highlighting different phases:

- Initial study of the process to monitor and forecast results.
- Experimental validation of the process by remote laboratory, comparison of theoretical and practical results with report writing.
- Feedback to the instructor with the information generated and activities feedback with improved functionality process the information from the instructor.

Using remote laboratories integrated in distance learning platforms should enable the improvement of the factors that affect metacognition: diversifying the types of theoretical material offered, adapting to different media (text, video, simulations, guided activities, remote monitoring of experiments, etc.) (Buiu, 2009). Using the possibilities and versatility of these formats that can be integrated in LMS that allows the theoretical contents to adapt to the abilities of each student. The possibility of working with standard learning objects, together with an environment that enables learning path planning, adapting the contents to the metacognitive profiles of students could improve the factors related to the self-regulation and therefore could lead to improvements in terms of student achievement. The integration of remote laboratories as learning objects, interspersing practical experience in theoretical training process would create a theoretical-practical flexible and adaptable environment for the users that will improve their results.

The flexibility in the learning process is bound up to both the formative itinerary planning and the capacities of the working environment in order to make it extensively available to the users. A booking system integrated in the LMS, allows extensive use of the laboratory continuously 24 hours a day 7 days a week (24/7) (Murray, 2012) and the inclusion of self-assessment tests, theoretical and practical that will allow the student to monitor his learning process.

Self-efficaccy can be improved by learning through observation of peers or teachers, sequencing tasks into more manageable elements of learning and frequent feedbacks about the work performed and how to improve it. It is important the inclusion of tutorials, video demonstrations and hands-on demonstrations by the instructor to ensure greater student confidence in using computers. One important factor that can help the Self-efficacy is the collaborative work so, some environments allow simultaneous management of multiple users connected on the same experiment, usually limited to a low number, three or four players at most users to not cause chaos in interacting with computers (Nedic, Machotka & Nafalski, 2008) as well as public demonstrations carried out by the instructor and monitored via webcam or graphic panels by students.

In order to break epistemological beliefs, communication elements and transmission of information between instructors and students are important to clarify expectations and the work performed with equipment. This is why the inclusion of communication tools between instructor and student (email, forums, reports, etc.) are important elements to include in the work environment.

As can be inferred from the preceding paragraphs, the attendance by teachers is a very important factor in the development of a constructivist space in e-learning. A limitation in some remote laboratories is the lack of assistance to the students (Böhne, Faltin & Wagner, 2002), so, the presence of an expert mentor is critical in the development of the learning strategies. The use of synchronous and asynchronous media to assist to the students can be performed in several ways:

- Give information and assistance to solve technical problems
- Stimulate the meta-cognition of the learners
- Advise of the learning goals and acting goals
- Give feedback to motivate the students
- Organize the learning process

To perform these tasks, the tutor may use the several applications that normally are integrated in a e-learning platform, as e-mail, forums, notice boards

## TIME FACTOR

The introduction of new technologies to manage time allows students to organize, plan and carry out their tasks in a flexible way to increase their learning capacities (Gadzhanov & Nafalski, 2010).

One of the first advantages of a remote laboratory is to break the barriers of classroom laboratories, where practices are tied to a specific space and limited in time. But the fact of having a remote laboratory 24/7 does not mean by itself that improves the flexibility and self-management ability of the student. Working overload or a bad planning can in some cases give the student a perception of excessive consumption of time for possible poor results with it (Corter, Nickerson, Esche & Chassapis, 2007). Therefore, the strategies of usage and time management should be related to the availability of the student, which will determine the effectiveness of working with these tools.

From the point of view of time factor, there are four important factors to be treated:

- **Access to the labs.** The remote labs must be the maximum time available for the users, with the necessary securities and access tools, allowing not concurrent use, except in the collaborative works or demonstrative exercises made by the teacher. Therefore, one remote lab must integrate a flexible booking system to manage the various services that it offers.

  From the point of view of the booking system that should be incorporated in the laboratory, it should be flexible enough to allow both instructor and student to develop their activities. On one hand the instructor should be able to **decide the experiences** that are to be performed and the system must incorporate and allow **easy removal of new equipment** to **create slots that can** be accessed as well as the **duration of practical** experience.

  On the other hand, from the point of view of the students' work, It is important for the booking system to allow knowing **the slots available** equipment and the free slots for reservation. But not only the system of reserve management is important, the RL must ensure that once the student accesses the computer Iit must be on the **initial conditions**, restarting previously the processes or experiments.

- **Time dedicated to each of the experiences.** The diversity of experiments in remote laboratories usually involves several actions by the user: **Preparing the equipment**, **experiment setup**, **execution of the experiment**, **gathering and analyzing results**. All these tasks may take from minutes to several hours or days depending on the experiment. So the first task for the instructor is to define the time needed for the experiment.

  Depending on the type of experiment, it is possible to define two categories: the **batch data processing**, where the user enters the data required for experimentation and processing queued, and when it ends they are shown or sent to the user and completely **interactively online.** The choice between one and other type, determines largely the degree of interactivity between the user and the experiment. Batch processing means that the user does not receive an immediate response of the experiment, while the process in online mode allows continuous observation and dynamic process and the user receives a continuous flow of numerical or graphical information that allows users to interact with the process changing the parameters of this and therefore their behavior.

- **Time dedication to the practical experiences in relation to all material available to the subjects.** One of the worst perceptions for a student on a course is that the time spent on practical experience is excessive compared to the results of academic knowledge finally acquired (Corter, Nickerson, Esche & Chassapis, 2007). Strategies that are carried out to adapt the temporary dedication to practical experience of academic results will greatly improve the student's perception.

It is important in this regard to have practical tutorials on how to access the lab and interact with the device and the computer prior to work with subject and its contents (Murray, 2012). It should help students to plan their work thorough the relationship of the theoretical and practical content. Also, it is important in this case to link practical experiences with theoretical material.

- **Flexibility in performing experiments.** Clearly, a distance learning environment has among its advantages the flexibility that the student perceives developing his studies in both time slots dedicated to carry out the tasks and the duration of these time slots. Increasing flexibility is certainly one of the strengths of learning systems using new technologies (Fox, 2005) The ideal laboratory environment should be a platform (hardware and software) ready to work with any kind of experimentation without changes in the environment (Costa, Alves & Zenha-Rela), therefore a first element from the point of view of the student is to have a common integrated environment for all subjects included in the curriculum.

  Furthermore, flexibility goes together with individualization of the learning process. This system should incorporate a library of practical experience that can be developed in remote laboratories, so that in this set of experiences, as discussed in the previous section, have to distinguish between the basic experiences of understanding the theoretical and the advanced experience, that users can choose other experiments based on their preferences. Thus, learning interest of the students increases (Wang Dai & Yao, 2010).

Improving the perception of the student in all these aspects is essential in achieving learning objects.

## CONCLUSIONS

As has been sated, design, creation and use of a remote teaching laboratory is a multidisciplinary task which involve from the design process, highly variable and dependent on the subject to teach, the information and communication technologies and finally to the didactic approach of its implementation.

The variety of remote laboratories proposals analysed has revealed a great heterogeneity of structures and very different approaches. In some way this heterogeneity precludes a systematic study of all didactic elements that have been developed.

One of the deficiencies, the result of the relatively short time that they have been applying these tools, it is possible that this area of knowledge has not yet reached a level of maturity that allows standardization of the elements involved in the definition of a remote laboratory analysis methodologies and teaching, but this is an area which already is starting up research and development proposals.

Self-regulation, closely related to the cognitive strategies used, self-recognition of one's skills by students and their planning and confidence in their capabilities are elements that have to strengthen in LMS platforms that include management tools, planning and collaboration to help students enhance their self.

On the Time Factor, tools to include access and booking laboratories, flexibility in the choice of the experiences and the relationship of time spent on the practical and theoretical content are essential. Finally assessment tools by the teacher must serve to strengthen monitoring and continuity of students.

The common framework to improve all these elements is to have an interface that includes tools tailored to improve each of the aspects involved. The emergence of open source LMS platforms, many modular types, has allowed many developers to design different modules that work in each of the areas studied.

As mentioned above, this heterogeneity proposals and studies focused on personal needs, determine that currently can find various solutions to each of the issues discussed. The time and research in each of these points will determine a convergence of these tools to a common and standardised study.

## References

Abdellaoui, N., Gravier, C., Belmekki, B. & Fayolle, J. (2010). Towards the loose coupling between LMS and Remote Laboratories in Online Engineering Education. *IEE EDUCON Education Engineering.* Madrid: IEEE.

Awkash, A. & Srivastava, S. (2007). WebLab: A generic Architecture for Remote Laboratories. *15th International Conference on Advanced Computing and Communications* (pp. 301-306). IEEE.

Böhne, A., Faltin, N. & Wagner, B. (2002). Self-directed learning and tutorial assistance in a remote laboraoty. *Interactive Computer Aided Learning Conference.* Villach, Austria.

Bauer, P., Fedak, V., Hajek, V. & Lampropoulos, I. (2008). Survey of distance laboratories in power electronics. *Power Electronics Specialists Conference PESC '08* (pp. 430-436).

Benseman, J. & Sutton, A. (2011). *OECD/CERI Formative Assessment Project backgorund report: New Zealand.*

Berge, Z. & Huang, Y. (2004). A Model for sustainable student retention; A Holistic Perspective on the Student Dropout Proble with special attention to e-learning. *SEOSNEWS*, *13* (5).

Bourne, J., Harris, D. & Mayadas, F. (2005). Online Engineering education: Learning anywhere, anytime. (S. Consortium, Ed.) *Journal of Asynchronous Learning Networks (JALN)*, *9* (i), 15-40.

Buiu, C. (2009). Design and evaluation of an integral online motion control training package. *IEE Transactions*, 385-393.

Bull, J. & McKenna, C. (2004). Blueprint for computer-assisted assessment. Routledge-Falmer.

Cabrera, M., Bragós, R., Pérez, M., Mariño, J. & Rius, J. GILABVIR: Virtual Laboratories and Remote Laboratories in Engineering. *EDUCON 2010* (pp. 1403-1408). IEEE.

Corter, J., Nickerson, J., Esche, S. & Chassapis, C. (2007). Cobnstructing Reality: A Study of Remote, Hands-On, and Simulated Laboratories. *ACM Transactions on Computer-Human Interaction*, *14* (2).

Costa, R., Alves, G. & Zenha-Rela, M. (n.d.). Reconfigurable weblabs based on the IEEE1451 Std.

Crisp, G. (2011). *Teacher's Handbook on e-Assessment.* Australian Learning and Teaching Council.

Dabbagh, N. & Kitsantas, A. (2004). Supporting self-regulation in student-centered web-based learning evironaments. *InternationalJournal on E-learning*, *3* (1), 40-47.

Fox, S. (2005). The New learning technologies in higher distance education: theoretical benefits through the prism of a case study. *The 11th cambridge international conference on open and distance learning*, (pp. 40-51). Cambridge.

Gadzhanov, S. & Nafalski, A. (2010). Pedagogical effectiveness of remote laboratories for measurement and control. *World Transactions on Engineering and Technology Education*, *8* (2), 162-167.

García-Zubía, J., Díaz Labrador, J., Jacob Taquet, I. & Canivell, V. (2008). Evaluación de los laboratorios remotos como herramienta docente. *Actas XIV jornadas de enseñanza universitaria de la informática* .

Gobbo, F. & Vaccari, M. (2005). Open standards for higher education in robotics by immersive telelaboratories. *Learning Technology Newsletter*, *7* (3).

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

Gregory Schraw, K., Hartley, K. & Hartley, C. (2006). Promoting Self-Regultaion in Science Education: Metacognition as part of a broader perspective on Learning. *Reseach in Science education, 36*,. 111-139. Springler.

Gustavsson, I., Nilsson, K., Zackrisson, J., Garcia-Zubia, J., Hernandez-Jayo, U., Nafalski, A., *et al.* (2009). On objectives of instructional laboratories, individual assessment, and use of collaborative remote laboratories.

Indrusiak, L., Glesner, M. & Reis, R. (2007). On the evolution of remote laboratories for prototyping electronic systems. *IEEE transactions on industrial electronics*, *54* (6).

Instruments, N. (2013, 01 05). *Software Labview*. Retrieved from www.ni.com/labview

Jung, I. (2005). Quality assurance survey of mega universities.

Kaczmarcyk, L. (2001). Accreditation and student assessment in distance education: Why we all need to pay attention. *6th Annu. Conf. ITiCSE 2001* (pp. 113-118).

Kidney, G., Cummings, L. & Boehm, A. (2007). Toward a quality assurance approach to e-learning courses. *International Journal on e-learning*, *6* (1), 17-30.

Larrauri, J., García, J. & Kahoraho, E. (2003). Integration of weblab systems in engineering studies. *International conference on engeenering education.* Valencia.

Laurillard, D. (1997). *Learning Formal representations through Multimedia.* Marton, Hounsell & Entwistle (eds).

Luís, G. & García-Zubía, J. (2007). *Advances on remote laboratories and e-learning experiences.* Bilbao: Deusto.

Ma, J. & Nickerson, J. (2006). Hands-On, Simulated, and Remote Laboratories: A comparative Literature Review. *ACM Computing Surveys*, *38* (3), 1-24.

Mathworks. (2013, 01 5). *Mathworks*. Retrieved from www.mathworks.com

McKavanagh, C., Kanes, C., Beven, F., Cunningham, A. & Choy, S. (2007). Evaluation of web-based felxible learning. *XIV Jornadas de Enseñanza Universitaria de la Informática* .

McKnight, C., Dillon, A. & Richardson, J. (1993). *Hypertext. A psycological persective.* New York: Ellis Horwood.

Meyen, E., Aust, R., Gauch, J., Hinton, H., Isaacson, R., J. Smith, S., *et al.* (2002). *e-Learning: A programmatic research construct for the future.* University of Kansas.

Murray, S. (2012). *Teaching techniques for using remote laboraotories.* Labshare Institute.

Nedic, Z., Machotka, J. & Nafalski, A. (2008). *Remote Laboratory NetLab for Effective Interaction with Real Equipment over the Internet.* Krakow, Poland: IEEE.

Nielsen, J. (1993). *Usability Engineering.* San Diego, California (EEUU): Academic press.

Oates, B. (2006). Researching Information Systems and Computing. Sage publications Ltd.

Paivio, A. (1971). *Imagery and verbal processes.* New York: Holt, Renihart & Winston.

Pintrich, P. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. Pintrich & M. Zeidner (Ed.), *Handbook of self-regulation* (pp. 452-501). San Diego, CA: Academmic Press.

Ramos-Paja, C., Ramírez Scarpetta, J. & Martínez-Salamero, L. (2010). Integrated learning plartform for internet-based contro-enginnering education. *IEEE transactions on industrial electronics*, *57* (10).

Reeves, T., Herrington, J. & Oliver, R. (2004). A developement research agenda for online collaborative learning. Educational Technology Research and Developement.

Rickey, D. & Stacy, A. (2000). The role of metacognition in learning chemistry. *Journal of Chemical education*, *77* (7), 915-919.

Rodriguez-Andina, J., Gomes, L. & Bogosyan, S. (2010). Current trends in Industrial electronics education. *IEEE transactions on industrial electronics*, *57* (10).

Rojko, A., Hercog, D. & Jezemik, K. (2009). Poweer engineering and motion control web laboratory: design, implementation and evaluation of mechatronics course. *Industrial Electronics*, *99* (1).

Roth, W. & Tobin, K. (2001). The implication of coteaching/cogenerative dialogue for teacher evaluation: Learning from multiple perspectives of everyday practice. *Journal of Personnel Evalauation in education*, *15* (1), 7-29.

Schaf, F. & Pereira, C. (2007). Automation and control learning environament with mixed reality remote experiments architecture. *International journal of online engineereing (IJOE)*, *3* (2).

Schnotz, W. & Zink, T. (1991). Informationssuche und Kohärenzbildung beim wissenserweb mit hypertext. *Zeitschrift für Pädagogische Psychologie*, 24-33.

Schraw, G. & Olafson, L. (2002). Teachers' epsitemological world views and educational practices. *Issues in education*, *8* (2), 99-148.

Schraw, G., Crippen, K. & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part broader on learning. *Reserach in Science education*, *36*.

Schunk, D. (1996). Goal and self-evaluative influences during children's cognitive skill learning. *American Educational Research Journal*, *33(2)*, pp. 359-382.

Spiro, R., Feltovich, P., Jacobson, M. & Coulson, R. (1991). Cognitive flexibility, constructivism, and hypertext. random access instruction for advanced knowledge acquisition in ill-structured domains. *Education technology*, 24-33.

Taylor, S. & Bogdam, R. (2002). Introducción a los métodos cualitativos de investigación. Paidós.

Tsai, C. (2001). Collaboratively developing instructuinal activities of conceptual change through the Internet: Science teachers'perspective. *British Journal of educational Technology*, *32* (5), 619-622.

Uran, S., Hercog, D. & Jezemik, K. (2007). Remote Control Laboratory with Moodle Booking System. (pp. 2978-2983). IEEE.

Wang, Y.-l., Guo, Z.-q. & Guo, q.-l. (2010). The research of teaching mode of netwrok experiment system. *2010 International conference on e-business and e-government.* Guangzhou: IEEE proceedings.

Wang, Z., Dai, Y. & Yao, Y. (2010). An internet-based e-experiment system for automatic control education and research. *Second International Conference on Communication Systems, Networks and applications* (pp. 304-307).

Weidenmann, B. (1997). Multicodierung und Multimodalität im Lernprocess. (L. I. P.Klimsa, Ed.) *Information und Lernen mit Multimedia*, 65-84.

Zimmerman, B. (2000). Attaining self-regulated learning: A social-cognitive perspective. In M. Boekaerts, P. Pintrich & M. Zeidner (Ed.), *Handbook of self-regulation* (pp. 13-39). San Diego, CA: Academic Press.