Teaching Power Electronics and Digital Electronics using Personal Learning Environments

From Traditional Learning to Remote Experiential Learning

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Mourad Gourmaj(✉), Ahmed Naddami, Ahmed Fahli, Driss Nehari
Hassan 1st University, Settat, Morocco
mourad.gourmaj@gmail.com

Abstract—Practical works have a fundamental role in the curriculum of any scientist, engineer, and technician. It helps learners to face the real world and put in practice what they have learned to judge their operability. Moreover, due to some limiting factors and due to the growth number of learners, universities and institutes have become inapt to give efficient learning. Distance education presents a future key to reduce these restrictions.

Currently, remote experiments together with web-based courses approach significantly contribute to many aspects of education for learners. In this context, the main question addressed is how we ensure that an educational system evolves to better serve the needs of learners? The present work proposes a solution based on student's Personal Learning Environments. Personal Learning Environments are educational platforms that help learners take control and manage their own learning process, learning modules with remote experiments, for reaching a specific goal. In order to response these criteria we use the Learning Management System Moodle, the e-portfolio Mahara, the Remote Laboratory Management System iLab Shared Architecture with additional tools and plug-ins to implement the learning by doing environment.

Keywords—Learning by doing, remote experiment, Personal Learning Environments, Remote Laboratory Management System, e-portfolio.

1 Introduction

The initial (primary to tertiary) or continuous, trainings should offer practical works to the students in order to master their theoretical knowledge. Practical works help learners to face the real word and put in practice what they have learned to judge their operability. The engineering studies aims to manipulate equipments, materials, energy, and information. Thereby creating benefit for humankind [1]. Further, it is important for engineers and scientists to have an efficient knowledge of nature, which goes beyond mere theory, to develop their understanding of the living world, ideas, theories, and models that scientists have found useful in explaining and predicting its behavior [2].

Methodologies and/or styles of education are changing almost at the same rate with the development of technologies and the increasing popularity of the Internet. Not only that, but new tools and resources are now available to facilitate the students access to knowledge. Hence, the urge to integrate those technologies into the educational process is increasing. Remote sessions/ remote laboratories which are based on the development of Internet technologies, implementation of information and telecommunication technologies. They have been considered as an increasingly popular innovation in engineering education. Moreover, remote labs have had an enormous impact on engineering as they help both students and teachers to access real experiments on real hardware at anytime they want and from anywhere through the Internet. Over the last decade, and due to many factors, more web-based laboratories have been integrated into educational process; and many institutes have explored the WWW to transfer their theoretical works and the activities of their laboratories towards distributed contexts [3]-[4].

A remote laboratory presents high-quality features and it is an easy way to perform experiments; the thing that distinguishes it from other simulated laboratories which do not use real equipment. Remote labs as a new concept and a new way of teaching urged many scientists and institutes to take their adoption into consideration and put them as a purpose of their works. The overall objectives of remote labs are:

- Digitalization of the educational process thought the implementation of new technologies and computer to manipulate and visualize a novel educational process;
- Reduce the number of hours that students have to spend in the laboratories by offering a self-paced learning;
- Offer practical experiments and pragmatic learning with real systems, using an equipment connected to the internet.

In recent years, several research groups from different universities have implemented platforms to develop remote laboratories. Some of these platforms combine prominent tools for Control Engineering and remote laboratories e.g., MATLAB/Simulink or LabVIEW etc [7]. To share remote labs, researchers have adopted RLMSs as the best middleware, since it has come with proficient guidelines and development toolkits for the management of these experiments. However, for a complete learning environment for the student, it is more common to use both educational systems, a Learning Management System (LMS), or Learning Content Management System (LCMS), and Personal Learning Environments (PLEs) etc, and remote labs in a single platform [5]-[6]. Blinding, and combining, remote labs together with virtual learning environment creates the perfect match for improving student practical skills. In this regard, it is true that through the use of those systems it is possible to provide access to online experimentation sessions from an uniform elearning context as well to do several activities e.g., sharing and discussing using online discussion, collaborating as well the knowledge creation with other learners etc. Thus, in case of using PLEs, learners are able to build and manage their own learning activities for achieving specific goals. Furthermore, PLE concept involves both formal and informal learning [8].

The focus of this contribution is to present a PLE based on LMS Moodle [32], RLMS iLab Shared Architecture (ISA) [9]- [10], Mahara e-portfolio[33] and other open source tools for enhancing laboratories/learning in engineering education and particularly in the field of electrical engineering. To reach that, a remote laboratory platform was developed. It is a remote control of electrical engineering instruments that allows their control in an interactive and easy way. The rest of this paper is structured as follows. Firstly, general background about PLEs is described in part 2. Some pedagogical concepts are analyzed and reported in part 3. The discussion and descriptions about the physical setup is addressed in part 4. The students' personal environment is described in part 5. Finally, part 6 highlights our conclusions, remarks, and future work.

2 Personal Learning Environments

In the last decade, information and internet technologies have been included in the educational process mainly to enhance the quality of the classroom. The use of LMS/CMS has allowed learners to complement face to face teaching, as well as to teach full-online courses [11]. Furthermore, the recent development of Web 2.0 technologies enables learners, in higher education, to mash up the learning resources, services, and communities according to their choices. Thus, web 2.0 technologies allow learners to use Wikis, RSS feeds, podcasts, YouTube, and social bookmarking tools. These technologies offer learners the easy way to engage in inquiry, creation of the learning content, to share educational resources and create collaborative knowledge [12].

Currently, more and more in the learning process, especially in the Science, Technology, Engineering, and Mathematics (STEM) subjects, the learner is considered as the main controlling element rather than the teacher or supervisors. Each learner has his/her own individual needs, choices and learning goals, which always greatly exceeds the numbers of teachers available to teach them [13]. Based on this context, PLEs came into the picture, where the distributed educational resources, tools, and laboratories are all integrated in a single virtual learning environment and customized by the individual learners according to their actual preferences and goals. As the name suggests, the PLE, describes the learner autonomy, services, communities, and shared resources that constitute the individual educational platform. Likewise, learners use PLE to create, control, and manage their own learning and pursue specific educational goals. The PLE can be described, according to Dawns as [34]: 'one node in a web of content, connected to other nodes and content creation services used by other students. It becomes, not an institutional or corporate application, but a personal learning center, where content is reused and remixed according to the student's own needs and interests. It becomes, indeed, not a single application, but a collection of interoperating applications-an environment rather than a system'.

3 Pedagogical Concepts

Laboratory activities for teaching practical skills in sciences and technologies are fundamentally a form of experiential learning [14]. Experiential learning is a fundamental paradigm within the theoretical tradition of adult education in Europe, North America and Australia. Experiential learning or 'Learning by doing' is a constructivist pedagogy approach; it is a process of learning and acquiring skills and expertise using experience in order to increase knowledge as a teaching pedagogy [15]. Following the constructivist learning theory as a constructive, situated and collaborative, process in which human develops, generates understanding knowledge and meaning of a domain by sharing, engaging their ideas and experiences from the interaction between them in practical idea [16]. In this sense and according to the mentioned information above, the use of remote laboratories for teaching and learning to acquire skills is based on the principle that learning and teaching is best achieved over experience. Learners learn by actively interacting and experiencing remotely with their environment through realistic experience as opposed to theoretical learning; this active involvement enhances learners' learning.

David Kolb's theory in the experiential learning built upon the earlier works of John Dewey and others. Kolb Professor of Organizational Behavior at the Weatherhead School of Management Case Western Reserve University, defines learning "Learning is the process whereby knowledge is created as the transformation of experience", so, knowledge results from the combination and interaction between theory and experience. It is based on the paradigm of constructivism theory [17].

Kolb's learning theory paradigm (known as the Kolb's Experiential Learning Cycle) sets out four distinct learning styles, which are schematized on a four-stage learning cycle. Kolb suggested, that any form of learning to be complete and effective requires that learner traces all the foundation of his learning flowing the cycle of four phases (Figure 1): Concrete Experience, Reflective Observation , Abstract Conceptualization ,and Active Experimentation

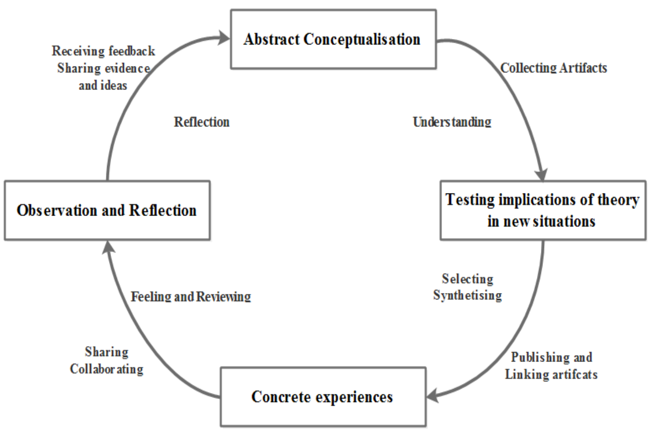

Fig. 1. A model of e-portfolio system for continuous learning, adapted from Kolb cycle

According to Kolb theory paradigm, an effective learning is achieved when a learner progresses over a cycle of four stages. In the Kolbian Cycle, the process begins having a concrete experience which means doing something in which the learner is assigned an experience (a new experience or a reinterpretation of existing experience), which is followed by a reflective observation on that experience. In this stage, the learner takes time-out from 'experiencing and doing', he asks various question related to the experience and reflects what has been accomplished and experienced. The Reflective Observation is then followed by the Abstract Conceptualization stage, in which the learner tries to form and conceptualize theory concepts about what they have done, and what is already known about an experience. In other words, the learner tries to generalize a theoretical model of what is practiced. Finally, the learner carries on to apply the generalized model to a new experience and situation [18].

The last stage 'Active Experimentation' leads to start another cycle to generate another concrete experience and new learning which is then followed by new reflection, observation and, based on them, reformulates the principle and again applies it. As shown in the figure1 and as described above, the Kolbian model is visualized as a cyclic process that repeats itself but each time on a more refined or sophisticated level due to the additional knowledge gained from the previous circle. According to Kolb in which views learning as an integrated process can be characterized as an iterative cycle. Each stage is an auxiliary and complement into the next. Thus, the learner is able to enter the learning cycle at any point and follows it through its logical sequence.

Using Kolb's paradigm of experiential learning to design and structure learners' web-based learning activities also helps us understand critical issues of remote student engagement, achievement, and satisfaction. Likewise, in [19] authors have conducted the following criteria about the assurance factors that impact student engagement, achievement, and satisfaction during online learning experiences:

- Knowledge is constructed.
- Students are responsible for their own learning.
- Higher-order learning requires reflection.
- Learning is unique to the individual.
- Learning is experiential.
- Learning is both social and private.

4 Physical Setup

The platform of remote experiments is developed using National Instruments (NI) software and hardware products [30], as: LabVIEW, NI compactRIO, FPGA and NI ELVIS. NI LabVIEW FPGA is a tool used to design all laboratories in this work for hardware implementations. The developed platform allows real interaction by students and the distant hardware in the laboratory by including real-time visualization, a NI CompactRIO controller and NI ELVIS were used in the implementation and the underlying software constructed in the NI LabVIEW coding the graphical environment.

The system includes a mixture of works divided into hardware and software. The hardware involves a working test that can be digitally controlled by computer and embedded controller. The software consists of a graphical user interface that allows users to control the test stations in a manner which closely resembles controlling the equipment in the real laboratory [20] - [21].

The first laboratory in electrical machine which consists of a real-time system to control remotely a synchronous machine includes several experiments such as (Figure 2 (b)):

- Real-time determination of the parameters of Open Circuit Characteristics (OCC);
- Real-time determination of the parameters of Short-Circuit Characteristics (SCC);
- Load test on synchronous machine;
- Synchronous reactance Xs.

The second laboratory in digital electronics includes several tests and experiments such as (Figure 2 (a)) [35]:

- Combinational logic circuits based experiments;
- Sequential electronics based experiments.

(a) (b)

Fig. 2. Physical infrastructure

5 Student's Personal Learning Environment

5.1 LMS Moodle

LMS Moodle is an Open Source web software package, provided free of charge (as part of the GNU Public License) that offers to educators and concepters the way to create dynamic web-based courses at anytime and anywhere. The license allows people to download, use and modify Moodle under the terms of the GNU Public License. Moodle is written in PHP and can be run using any web server, such as Apache HTTP Server. The use of LMS Moodle offers the easy way to deploy and share courses and resources as well as, the integration of remote labs. Further, it offers to students to participate in online activities as: online discussions, communication with students or instructors, assessments, online project/collaborative work, which replace part of face-to-face teaching and learning activities.

5.2 RLMS ISA

The ISA is a remote laboratory management system developed by the CECI at the MIT. The ISA provides a common framework on which laboratory instrumentation can be integrated to create remote laboratories that allow students to conduct and run laboratory equipments remotely through the internet, also designed to use online labs to scale a large number of users geographically dispersed through the world. ISA, based on Web Services, provides a three-tiered architecture software framework designed for enabling institutes easily sharing different remote laboratories across the world. This architecture consists of a Lab Clients, Service Broker middleware, and Lab Servers. The service broker is the heart and the component responsible for providing generic functionalities such as managing, scheduling, data storage. It also provides all management resources and experiments [22].

The idea to integrate remote laboratories, deployed into RLMS ISA, into LMS Moodle gives students and teachers the easy way to meet and where students find more educational resources [29]. Thus, this linkage in a single environment provides an integral environment to students and use learning content and remote experiment using the same credentials. The integration tool is called Lab Manager which connects the LMS Moodle with the RLMS ISA. So, students are able to perform a remote experiment with a single sign on directly from Moodle connect to RLMS ISA platform, more details about the tools are available in : https://github.com/gateway4labs/rlms_ilabs/.

5.3 E-Portfolio

Modern technologies have widely changed the way in which learners in higher education learn and experience, particularly in terms of access and use. A concept of current interest that foster the personalization, collaboration, and creativity of learners – is so-called e-portfolio [23] [24]. The e-portfolio is a paradigm, based on the Information and Communications Technology (ICT), in which learners are able to store all resources and knowledge in electronic form [25]. An e-portfolio, as one application of PLE, is a digitized collection of artifacts for teachers, learners, and institutes. Furthermore, learners can build their own e-portfolios following defined goals and objectives; they manage and control themselves to be more autonomous in the learning process and to promote decisions-making with the teacher's guidance [24]- [25].

As mentioned before, an e-portfolio exhibit a collection of digital artifacts representing hard work for deep and continuous learning. In this sense, the use of e-portfolio is like learning passports, as they progress continuously from one stage of learning to another. This makes the learning a living and breathing entity which can see it growing and know how it grew and why. The e-portfolio is characterized as a constructive learning tool [25]. The Kolb experiential paradigm presents an ideal learning cycle that illustrates the process of continuous learning based around dialogue and collaborative activity with others. The Kolbian cycle includes learner-centered learning and the learners have to become more active and responsible for their own learning. The e-portfolio system is perfectly adapted to support the Kolb's Experiential Learning Model because it has to do with planning, sharing, learning by doing, reviewing, and reflecting on previous evidence.

They are various solutions to implement e-portfolios, in this work we are using the Mahara open source which can be easily combined with the LMS Moodle already used as to deliver theoretical courses for our learners. The combination, or the integration, of Moodle and Mahara, is officially called "Mahoodle" [31]; this integration is usually to create a complete and compressive learning environment using single sign-on as well the transfer of content (Figure 3).

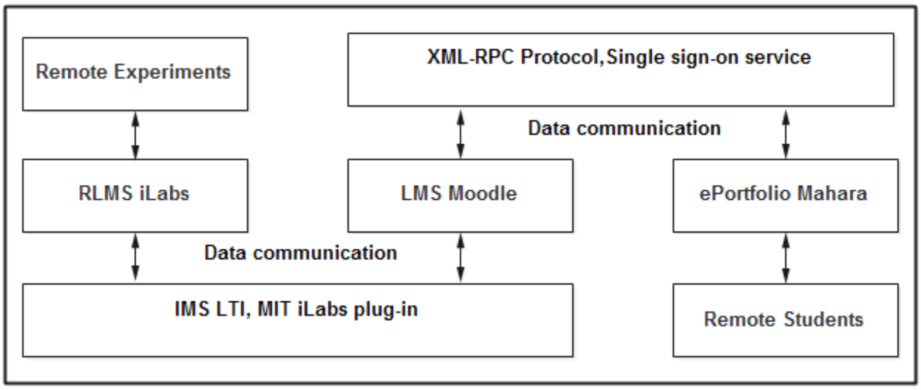

Fig. 3. Data integration (ISA & Moodle, Moodle and Mahara)

In order the foster the active learning, the e-portfolio presents a powerful tool that allows learners and teachers, to product and manages virtual space for personal, academic and professional purposes.

e-portfolio as a tool for Assessment. Assessment, alternative assessment, is a fundamental component of the educational process for any level and curricula. [13] defines that an alternative assessment is : "any method of finding out what a student knows or can do that is intended to show growth and inform instruction and is not a standardized or traditional test". In this regard, the alternative assessment its more focused on learner's knowledge, performance, growth and skill development. In fact, a teacher needs to assess this process and identify learners knowledge, abilities, and achievements behind a course or module. In recent years e-portfolios have been used in higher education as an assessment tool by many educators and universities. It allows the teacher to better track the progress of learners and their achievements for specific or different goals [26].

In this work, for Power Electronics and Digital Electronics courses, a learner's e-portfolio can contain various artifacts and resources might reflect the progress and achievements in his/her learning. Some of the possible artifacts and materials are:

- Solution of the exercises and reflection /questions, ideas, and about some specific goals;
- Measurements, equipments /procedures, results, and discussion about remote experiments as well lab report;
- Collaborative or personal project about digital systems and power electronics;
- Many online experiments, virtual experiments, was embedded into Moodle; learners in this case are able to compare between realistic and virtual data as well linking the theory and the practice.

A set of large variety of question types can be used by teachers to evaluate student learning, for summative assessment, at the end of an instructional unit. The questions include: multiple choices, unique choice, true-false, and short answer questions. Thus, summative assessments are often high stakes, which contains midterm and final exam. Furthermore, learners can submit any digital content to her/his teachers directly using Moodle.

Learning by doing using e-portfolio. By creating and designing their own e-portfolios system, learners can demonstrate authentic learning. Moreover, they can exhibit their works, projects, links and resources about specific goals or aims. For example, learners perform an experience of digital electronics (such as: 4 binary counter) or electrical machine (such as: determination of the synchronous reactance experiment). In this sense, learners are able to discuss and analyze graphical diagrams and chronograms as well as they see the behavior of circuits. Likewise, they use the synchronous and asynchronous communication offered to discuss and analyze the results, thoughts of these experiments also about what has been done and experienced.

All the learners are requested to write up a lab report (achievements, measurements thoughts, and ideas, etc) for each experiment performed and submit it using Moodle. Learners submit their lab report to specific folders which could be accessed by their teachers. After providing comments and remarks, learners share their lab reports with other learners using e-portfolios. In this way, learners become authors/designers and publishers of the e-content with a minimum level of guidance. In fact, this collection of structural knowledge, social interaction, social constructivist approach, foster the learners creativity to work towards valuable education goals. Furthermore, It is important to note that these criteria allow the student to better understand and identify their gaps in a specific goal during the learning by doing (Figure 4).

e-portfolios as a Gateway between university and company. The courses in the case of Power Electronics and Digital Electronics are taught within an official national graduate degree program as a complement to contents in the regular teaching, called Electrical Engineering And Industrial Computing. This degree program was created to answer the labor market demands by increasing the rate of training and forming of proficient qualified engineers and technicians. In the final year, to graduate from this degree program, all students must complete a minimum of 60 days as a trainee in the industry. By using their e-portfolios, students are able to showcase their experiences, skills, professional capabilities in power electronics and digital electronics, as well in other courses [27]-[28], in an interactive and creative way when applying for internships. In this context, e-portfolios enable students take advantage of the

21st-century technology skills and demonstrate their competencies and store their works, internships, personals and collaborative projects/realizations in the aforementioned fields that may not be demonstrated on a traditional résumé or during an interview. In this way, supervisors in the company are able to access from any Internet-enabled computer to student's e-portfolio and see what the student has acquired during his/her 3 years study in this field. Besides, during the traineeship the student can still work, and update her/her e-portfolio with new knowledge, skills, and competencies. Generally speaking, the e-portfolio will allows student as a trainee to:

- Reflect on theory and practical knowledge acquired through the new experience in the company;
- Capture and record the relevant experiences, artifacts, and skills that reflect professional growth during the traineeship;
- Show commitment, individual endeavor, and creativity during the traineeship.

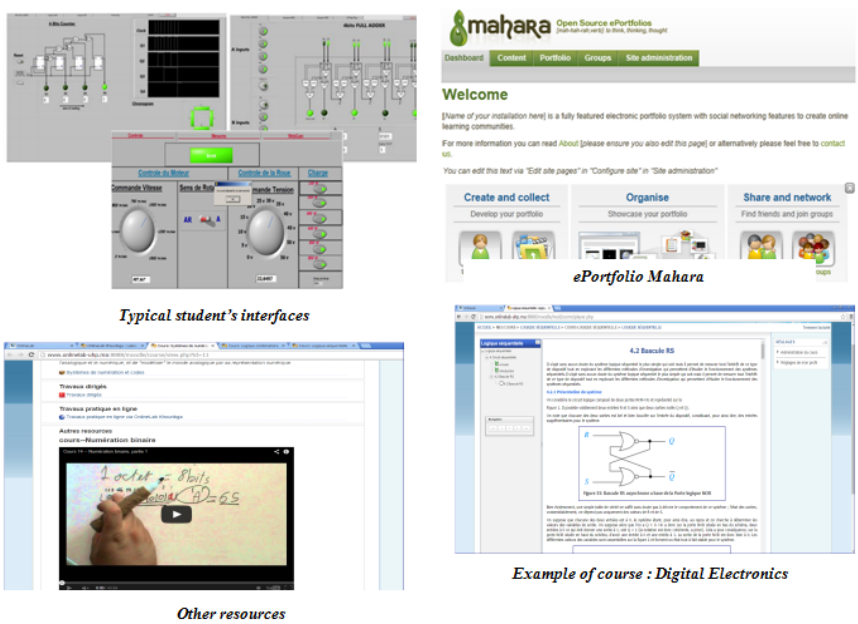

Fig. 4. Student's learning environment

6 Conclusion and future works

Modern and emergence technologies have widely changed the way in which learners in higher education learn and experience, particularly in terms of access and use. Modern higher education in the 21st century requires new teaching and learning concepts to better serve the need of learners. Therefore, learning through experiment, in addition to the active use of laboratories in higher engineering education, has become one of its essential parts. Our educational process behind our approach is remote learning by experience using a personal learning approach. Furthermore, this educational method that calls for reflection, analysis and planning can directly involves the learners by actively encouraging them to do something in order to observe and understand what is happening and experiencing.

Through our experience by using and combining ISA and Mahoodle platforms, Moodle and Mahara, we can conclude that this combination is a good tool to link learners and teachers and vice versa. The e-portfolio has the potential as an effective tool in learning by doing to enhance the creativity, communication, collaboration and learning process among students. Thus, it may be used to support lifelong learning activities through embedding and storing tools electronically for professional skills and needs.

Regarding future work, ongoing efforts are focused on analyzing and examining of the students' attitudes towards the use of e-portfolio's as a teaching tool in higher education.

7 References

[1] A. J. Feisel, Lyle D.; Rosa, "The role of the laboratory in electrolyte therapy" Can. J. Med. Technol., vol. 16, no. 1, pp. 1–4, 1954.

[2] R. Millar and I. Abrahams, "Practical work : Making it more effective," vol. 91, no. September, pp. 59–64, 2009.

[3] A. Mohtar, "A Remote Laboratory for Testing Microelectronic Circuits on Silicon Wafers under a Microscope," University of South Australia, 2009.

[4] M. S. T. Abuelela, "Laboratory as a Service (LaaS): a Paradigm for Developing and Implementing Modular Remote Laboratories," National University of Distance Education, 2013.

[5] E. Sancristobal, M. Castro, J. Harward et al., "Integration view of web labs and learning management systems," in Education Engineering (EDUCON), 2010 IEEE. IEEE, 2010, pp. 1409–1417.

[6] P. Orduna, E. Sancristobal, M. Emaldi, M. Castro, D. Lopez-De-Ipina, and J. Garcia-Zubia, "Modelling remote laboratories integrations in e-learning tools through remote laboratories federation protocols," Proc. - Front. Educ. Conf. FIE, pp. 1–6, 2012.

[7] R. Puerto, L. M. Jimenez, O. R. C. Fernandez, and R. Neco, "Remote control laboratory using MATLAB and Simulink: Application to a DC motor model," Comput. Appl. Eng. Educ., vol. 18, no. 4, pp. 694–702, Dec. 2010. https://doi.org/10.1002/cae.20274

[8] C. Patterson, M. Stephens, V. Chiang, A. M. Price, F. Work, and E. Snelgrove-clarke, "The significance of personal learning environments (PLEs) in nursing education: Extending current conceptualizations," NEDT, vol. 48, pp. 99–105, 2016.

[9] Kimberly DeLong, V. Judson Harward, Philip Bailey, James Hardison, Gordon Kohse, Yakov Ostrocsky "Three Online Neutron Beam Experiments Based on the iLabShared Architecture", Education Engineering (EDUCON), Madrid, pp.145 – 150, 14-16 April 2010.

[10] Hardison, J., DeLong, K., Bailey, P., Harward, V.J., "Deploying Interactive Remote Labs Using the iLab Shared Architecture," Frontiers in Education (FIE) Conference, Saratoga Springs, New York, October 22-25, 2008. ILab https://doi.org/10.1109/FIE.2008.4720536

[11] E. Rahimi, J. van den Berg, and W. Veen, "Facilitating student-driven constructing of learning environments using Web 2.0 personal learning environments," Comput. Educ., vol. 81, pp. 235–246, 2015. https://doi.org/10.1016/j.compedu.2014.10.012

[12] Isaksson E, N. A, L. P, and W. F, “Towards a Reference Architecture for Smart and Personal Learning Environments,” in Innovations in Smart Learning, Springer Singapore, 2016, pp. 79–88.
[13] O. L. Colin D. Milligan, Phillip Beauvoir, Mark W. Johnson, Paul Sharples, Scott Wilson, “Developing a Reference Model to Describe the Personal Learning Environment,” in First European Conference on Technology Enhanced Learning, 2006, pp. 506–511.
[14] M. Abdulwahed, “Towards Enhancing Laboratory Education by the Development and Evaluation of the ‘Trilab’ -- a Triple Access Mode (Virtual, Hands-On and Remote) Laboratory,” 2010.
[15] J. M. Applefield, R. Huber, and M. Moallem, “Constructivism in Practice and Theory: Toward a Better Understanding,” High Sch. J., vol. 84, no. 2, pp. 35–53, 2001.
[16] L. Harasim, Learning Theory and Online Technologies. 2012.
[17] D. A. Kolb, Experiential learning: experience as the source of learning and development. 1984.
[18] L. Ngoyi, “enefits and Challenges Associated with Using Virtual Laboratories and Solutions to Overcome Them,” Virginia State University, 2013.
[19] J. Dunlap, J. Dobrovolny, and D. Young, “Preparing e-Learning Designers Using Kolb’s Model of Experiential Learning,” J. Online Educ., vol. 4, no. 4, 2008.
[20] Naddami, A., Fahli, A., Gourmaj, M. and Moussetad, M. (2014), Determination of the synchronous machine's parameters using the iLab Shared Architecture ", IJOE, Vol 10, No 3 .
[21] Naddami, A., Fahli, A., Gourmaj, M. Pester, A. and Oros, R. (2014), Importance of a network of online labs in magrebian countries Proceedings of the IEEE , REV14 Conference, pp.77-78, Porto 26-28 February, 2014
[22] Harward, V.J., et al (2008), "The iLab Shared Architecture: A Web Services Infrastructure to Build Communities of Internet Accessible Laboratories," Proceedings of the IEEE, vol.96, no.6, pp.931-950. https://doi.org/10.1109/JPROC.2008.921607
[23] L. Valdez, O. Malley, and J. Michael, “Performance and Portfolio Assessment for Language Minority Students,” 1992.
[24] C. P. C. Terkowsky, D. May, T. Haertel, “Integrating Remote Labs into Personal Learning Environments-Experiential Learning with Tele-Operated Experiments and E-Portfolios,” Int. J. Online Eng., vol. 9, no. 1, pp. 12–20, 2013. https://doi.org/10.3991/ijoe.v9i1.2364
[25] Ruhizan M.Y, Norazah. M. N, and Bekri. R, “Vocational Education Readiness In Malaysia On The Use Of E-Portfolios,” J. Tech. Educ. Train., vol. 6, no. 1, pp. 57–71.
[26] E. Ntuli and J. Keengwe, “Electronic portfolios in teacher education: A case study of early childhood teacher candidates,” Early Child. Educ. J., vol. 27, no. 2, pp. 21–22, 2009. https://doi.org/10.1007/s10643-009-0327-y
[27] K. S. Mazlan, L. Khoo, M. Sui, and Z. Jano, “Designing an Eportfolio Conceptual Framework to Enhance Written Communication Skills among Undergraduate Students,” Asian Soc. Sci., vol. 11, no. 17, pp. 35–47, 2015. https://doi.org/10.5539/ass.v11n17p35
[28] B. Wuetherick and J. Dickinson, “Why ePortfolios ? Student Perceptions of ePortfolio Use in Continuing Education Learning Environments,” Int. J. ePortfolio, vol. 5, no. 1, pp. 39–53, 2015.
[29] P. Orduna, S. Botero Uribe, N. Hock Isaza, E. Sancristobal, M. Emaldi, A. Pesquera Martin, K. DeLong, P. Bailey, D. Lopez-de Ipina, M. Castro ´ et al., “Generic integration of remote laboratories in learning and content management systems through federation protocols,” in Frontiers in Education Conference, 2013 IEEE. IEEE, 2013, pp. 1372–1378.
[30] National Instruments. (2016, September 4). [Online]. Available: http://www.ni.com/

[31] Mahoodle. (2017, January 20). [Online]. Available: https://docs.moodle.org/29/en/Mahoodle
[32] Moodle. (2017, January 20). [Online]. Available: https://moodle.org
[33] Mahara. (2017, January 20). [Online]. Available: https://mahara.org/
[34] Stephen Downes. (2016, October 13). [Online]. Available: http://www.downes.ca/post/
[35] Online laboratory in Digital Electronics using NI ELVIS II+, Naddami.A, Fahli.A, Gourmaj.M, Moussetad.M, Proceedings of the IEEE , IMCL14 Conference, pp. 120 - 124, 2014

8 Authors

Mourad Gourmaj (corresponding author) is with the MATIC Laboratory, Department of Electrical Engineering, The Polydisciplinary Faculty in Khouribga, Hassan 1st University-Settat 26000, Morocco (e-mail: mourad.gourmaj@gmail.com).

Ahmed Naddami is with the MATIC Laboratory, Department of Electrical Engineering, The Polydisciplinary Faculty in Khouribga, Hassan 1st University-Settat 26000, Morocco (e-mail: ahmed.naddami@gmail.com).

Ahmed Fahli is with the MATIC Laboratory, Hassan 1st University-Settat 26000, Morocco (e-mail:fahli@uhp.ac.ma).

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