UNIVERSIDADE DO ALGARVE
FACULDADE DE CIÊNCIAS E TECNOLOGIA

A FEDERATION OF ONLINE LABS FOR ASSISTING SCIENCE AND ENGINEERING EDUCATION IN THE MENA REGION

RAZWAN MOHMED SALAH NAJIMALDEEN

Tese de Doutoramento em Engenharia Informática

Trabalho efetuado sob a orientação de:

Pedro Guerreiro e Gustavo Ribeiro Alves

2017

A Federation of Online Labs for Assisting Science and Engineering Education in the MENA Region

PhD Thesis in Informatics Engineering

by RAZWAN MOHMED SALAH NAJIMALDEEN

From the University of Duhok, Duhok, Kurdistan Region, Iraq

Supervisors:

Professor Pedro Guerreiro, Department of Electronics Engineering and Informatics, Faculty of Science and Technology, University of Algarve, Faro, Portugal.

Professor Gustavo Ribeiro Alves, Department of Electrical Engineering, School of Engineering, Porto Polytechnic, Porto, Portugal.

2017

STATEMENT OF ORIGINALITY

A FEDERATION OF ONLINE LABS FOR ASSISTING SCIENCE AND ENGINEERING EDUCATION IN THE MENA REGION

Statement of authorship: The work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text. The material has not been submitted, either in whole or in part, for a degree at this or any other university.

Candidate

____

(Razwan Najimaldeen)

Writing is easy. All you do is stare at a blank sheet of paper until drops of blood form on your forehead. --- Gene Fowler (1890-1960)

PREFACE

"I Believe I Can Fly"

After I completed my MSc degree in 2009, I started to open doors in my mind by asking myself: what shall I do now to help and support my home universities? How can I develop my academic skills? Is an MSc degree enough for me? plus other questions. Finally, I got the answer to all these questions and it was: I have to continue studying by starting a PhD degree, so I said to myself "Let's go to open a new chapter in my life".

I applied to many programs and then finally I was awarded a grant by Erasmus Mundus Lot8, to start doing a PhD degree at the University of Algarve, in Portugal. Really, it was a great opportunity to start a new chapter of my life in Portugal.

In fact, I have figured out that PhD students must be ready for a long battle. These lines are the report of this long process. It cannot express the long days spent in the lab, shoulder to shoulder with my fellow scientists and supervisors, the joy for the synthesis, the hope for good results, and the sadness and tiredness with each failed attempt. Really, it was a beautiful journey in my PhD life, I have no regrets whatsoever, even if leaving some of the pain behind me.

Shortly, the first year of my PhD course was a bit hard because I lived it alone, far away from my family (wife and son aged 2 and a half years), and I started with a new field - *online labs*– on which I have never worked on before. Overall, with family and supervisors support I moved forward systematically and have been able to organized well the main issues. A special day in this journey was November 2, 2016. On that day, I received a most precious gift: Aram, my second son, was born. One of the greatest moments of my stay in Portugal was having my baby look at me for the first time and say "Olá" with his eyes. One day, I will become a storyteller by recounting this journey to my sons. I am looking forward and waiting for that day.

In result, at every turning of my life I came across to know good friends. Friends who stood by me, even when the time raced me by who have become the strong arms that held me up, and who fed me with full of love.

Now, do you know why I have chosen these words "**I Believe I Can Fly**"? I am going to tell you now. This is the title of one song by R. Kelly. Some days ago I heard my son, Yousif, singing this song and he now always says “I believe I can fly”. So, I imagine Yousif, six years old, is starting to have dreams and that he would like to achieve them. I hope his dreams come true.

Finally, thanks to you too, my Reader. I hope you will find that my work is interesting and useful, and that you will be able to catch a glimpse of what my journey was like.

Sincerely,

Razwan Mohmed Salah Najimaldeen

SUMMARY

By Razwan Najimaldeen

Education is now more widely available than ever before. In a great part, this is due to the usage of digital tools, applications and online services by students and teachers. In fact, the Internet has hugely increased the availability of educational resources and also prompted additional collaboration and cooperation among institutions and among countries.

Today, active learning methods offer several techniques that have been adopted by teachers to bring efficient learning experiences for the students. Learning by doing promotes successful learning by providing varied experiences to the students in Science, Technology, Engineering and Mathematics (STEM) fields. In addition, with continued practice, the students learn the contents of lessons and develop their skills by using all available resources. This leads to effective learning and effective acquisition of knowledge, and helps in building a strong relationship among students and between them and their teachers.

In recent decades, instructional technologies have supported higher education systems well. They have offered several active learning methods to institutions, for instance online labs. Several projects in online labs area are being done worldwide, at present. Generally, the supporting idea of online labs is to offer additional access to remote experiments to students in different disciplines, 24/7 without substantial increase in cost per student around the world and especially in countries with limited resources. Moreover, they allow students to spend more time on experiments and increase their ability and skills through a simple computer connected to the Internet.

This study focuses on the higher education systems in the Middle East and North Africa (MENA) region. It discusses the level of collaboration and cooperation work among researchers in this region, particularly in online labs fields. It offers new perspectives and new ways to increase that work by creating the Community of Practices (CoP) around online labs and also by promoting the idea of federation new and existing online labs.

Keywords: MENA Region; Higher Education System; Collaborative and Cooperative Work; Online Labs, VISIR Open Lab Platform, Community of Practices (CoP); Online Labs Federation

RESUMO

By Razwan Najimaldeen

O ensino é, hoje em dia, mais acessível à generalidade da população mundial do que em qualquer momento do passado. Isso deve-se, em grande parte, à utilização de ferramentas digitais, de aplicações informáticas e de serviços online, pelos professores e pelos estudantes. Com efeito, a Internet fez aumentar imenso a disponibilidade de recursos educativos e, simultaneamente, proporcionou o desenvolvimento dos intercâmbios e das colaborações entre as instituições de ensino superior e entre os diversos países.

As várias técnicas que integram os métodos de ensino ativo têm vindo a ser adotadas progressivamente pelos professores, dessa maneira proporcionando aos estudantes percursos de aprendizagem mais aliciantes e mais profícuos. *Aprender fazendo* promove o sucesso na aprendizagem por via da realização de experiências práticas nos vários domínios da Ciência, Tecnologia, Engenharia e Matemática. Além do que, dessa maneira os estudantes assimilam os conteúdos programáticos e desenvolvem as suas capacidades, atingindo mais eficazmente os objetivos do estudo. Isto conduz a uma aprendizagem mais conseguida e a uma real aquisição de conhecimentos, fomentando, ao mesmo tempo, um relacionamento mais forte entre estudantes e também entre estudantes e professores.

Nas últimas décadas, o funcionamento das instituições do ensino superior tem vindo a apoiar-se cada vez mais nas tecnologias de ensino. Entre as diversas tecnologias que foram adotadas, contam-se os laboratórios *online*. Existem, atualmente, diversos projetos neste domínio, com vasta cobertura. Resumidamente, a visão dos promotores dos laboratórios *online* é proporcionar aos estudantes das diversas disciplinas acesso remoto a experiências práticas, 24 horas por dia. Isto deve ser conseguido sem que as instituições de ensino superior tenham de incorrer em gastos substanciais, de modo a possibilitar a adoção dos laboratórios *online* por países que atravessem dificuldades económicas. Com os laboratórios *online*, os estudantes têm oportunidade de realizar mais experiências do que realizariam de outro modo e, assim, desenvolver mais eficazmente as suas capacidades científicas e tecnológicas. E isso conseguir-se-á por via de um simples computador ligado à Internet.

O presente estudo centra-se nos sistemas de ensino superior dos países do Médio Oriente e do Norte de África, em inglês, *Middle East and North Africa*, MENA. Analisamos, em particular, o nível de colaboração existente entre os investigadores desta região, no domínio dos laboratórios *online*, e propomos novas perspetivas para o desenvolvimento do trabalho desses investigadores, por meio de da criação de uma comunidade de prática (em inglês *community of practice*) sobre o tema dos laboratórios *online*. Adicionalmente, propomos a criação de uma federação de laboratórios *online*, que agrupará laboratórios dispersos pelo mundo, já existentes ou a criar, assim facilitando a sua utilização à escala mundial.

Palavras-chave: Região MENA; Sistemas de ensino superior; trabalho colaborativo e cooperativo; laboratórios *online*; plataforma VISIR Open Lab; comunidades de prática; federação de laboratórios *online*.

ACKNOWLEDGEMENTS

Prima face, I am grateful to Allah for the good health and wellbeing that were necessary to complete this study.

I would like to mention that this work has been supported by the Erasmus Mundus Program- Lot 8, and by collaborative work between the University of Algarve (UAlg), and the Polytechnic of Porto – School of Engineering (IPP-ISEP).

Firstly, I would like to express my sincere thanks to my great supervisors, **Prof**. **Pedro Guerreiro** from UAlg and **Prof**. **Gustavo Alves** from IPP-ISEP, for their assistance in the preparation to complete this PhD degree by providing the necessary facilities for the research. Thank you for encouraging my research and allowing me to grow as a scientist. Both of you have been tremendous mentors for me.

I express my deepest thanks to the International Research & Exchanges Board (IREX) organization for funding Building a Remote Experimentation Network for serving higher education teachers and students in Iraq (REXNet), a joint collaborative project involving the Oklahoma State University, the university of Duhok (my home institution), the University of Zakho, and the Polytechnic of Duhok. They have given me advices, guidance, and arranged all facilities to make this study easier, especially **Ms**. **Lori Mason** and **Dr**. **Joe Cecil**. I choose this moment to gratefully acknowledge their contribution.

A special thanks to my parents, sisters, and brother for all of the sacrifices that you have made on my behalf. Your prayers for me were what sustained me thus far. Thanks to my parents for their faith in me, and allowing me to be as ambitious as I wanted to. Also, thanks to my father in law and his family for supporting me during this PhD course. Words cannot express how grateful I am now to you all.

Special love and thanks to my lovely family (Soul-mate "**Jiman,** and my lovely kids "**Yousif** and **Aram"**) for your support, encouragement, quiet patience and unwavering love. You were undeniably the bedrock upon which the past years of my life have been built. Jiman, your tolerance of my moods during study, your unyielding devotion and love were great.

I would also like to thanks **Marleni, Célia, and Mercês** from mobility office, and **Prof. Amine Berqia** from the UAlg, **Frederico, Ruben** and other staff of Physics department from the IPP-ISEP, my friends **Diyar, Beata, Kees, Shamil, Yaseen, Anwer, Nawzat, and Smail** for their support and strive towards my goal.

At the end, I would like to express appreciation to **Prof. Gustavo's** family for being a family friend during our stay in Porto. In addition, thanks to **Rosario** for spending times with us during life in Faro. Thanks to **Mr. Norberto Santos and Hussain AlSwaidi, Mrs. Sulaf AlShikaky and Taghreed Numan**, for their support as well. Thanks for all the people from Portugal for the hospitality and lovely years that I spend over there.

Last but not less, I also place on record, my sense of gratitude to all my friends who, directly or indirectly, have let their hand in this study.

Thank you to all for being the part of this journey. It was a great honour to me. I could not have done it without you. ☺☺

Sincerely,

Razwan Mohmed Salah Najimaldeen

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

MENA	Middle East and North Africa
ICT	Information and Communication Technologies
VISIR	Virtual Instrument Systems in Reality
CoP	Community of Practice
iCEER	International Conference on Engineering Education and Research
REV	International Conference on Remote Engineering and Virtual Instrumentation
EDULEARN	International Conference on Education and New Learning Technologies
TEEM	International Conference on Technological Ecosystems for Enhancing Multiculturality
iCERi	International Conference of Education, Research and Innovation
NGNs	Next Generation Networks and Services
EDUCON	IEEE Global Engineering Education Conference
IJHCITP	International Journal of Human Capital and Information Technology Professionals
iJOE	International Journal of Online Engineering
REXNet	Building a Remote Experimentation Network for serving higher education teachers and students in Iraq
IREX	International Research & Exchanges Board
ITP	Information Technology & People
MOOCs	Massive Openly Online Courses

STEM	Science, Technology, Engineering and Mathematics
WISE	World Innovation Summit for Education
LMS	Learning Management System
Moodle	Modular Object-Oriented Dynamic Learning Environment
ISA	iLab Shared Architecture
GOLC	Global Online Laboratory Consortium
SIG	Special Interest Group
PXI	PCI eXtensions for Instrumentation
PCI	Peripheral Component Interconnect
DMM	Digital Multi-meter
PCIe	Peripheral Component Interconnect Express
FGENA	Function Generator
BNC	Bayonet Neill-Concelman (connector)
MCX	Micro Coaxial
PCB	Printed Circuit Board
TCP/IP	Transmission Control Protocol/Internet Protocol
HTML	HyperText Markup Language
IAOE	International Association of Online Engineering
LXI	LAN eXtensions for Instrumentation
CICs	Continental and Intercontinental Communities
RNCs	Regional and National Communities

SWOT	Strengths, Weaknesses, Opportunities, and Threats
RLMSs	Remote Laboratory Management Systems
SSO	Single Sign-On
VRLE	Virtual Reality Based Learning Environment
PILAR	Platform Integration of Laboratories based on the Architecture of visiR
3Fs	Three Factors
CPLD	Complex Programmable Logic Device
FPGA	Field Programmable Gate Array
FIE	Frontiers in Education

LIST OF APPENDICES

"Education in our times must try to find whatever there is in students that might yearn for completion, and to reconstruct the learning that would enable them autonomously to seek that completion"

Allan Bloom (1930-1992)

CHAPTER 1.

INTRODUCTION

Abstract

In recent years, the emergence of a large variety of instructional technologies has become a reality. This is due to the advent and rapid evolution of ICT along with the rapidly evolving challenges faced by higher education systems. Instructional technologies, for instance online labs, have become networks consisting of a variety of entities (such as institutions, teachers, researchers, and students) that are geographically distributed and heterogeneous in terms of their operating environment, culture, and autonomy. These entities interact for achieving their common goals, for example supporting higher education systems and increasing collaborative and cooperative work. Furthermore, the efficiency and effectiveness of online labs use and its activities depend on how good the interaction among the online labs partners is.

1.1 BACKGROUND AND MOTIVATION

Today, education is considered a major factor in the economic expansion and is a fundamental component of any development strategy around the world. The main objective of developing higher education is to shape the students personality and bring them to the twenty-first century to understand the nature of systems in which they work and live in [1].

ICT has become essential in higher education systems and crucial to the pedagogical models used for modernizing them [2][3][4]. ICT generally refers to technology that is used to access information via Internet plus their tools and application software. In result, it allows learners to collaborate and cooperate with others worldwide [2].

Generally speaking, ICT have an impact on education such as: i) make students and teachers familiarize with computers and its applications [2], ii) enhance teaching and learning processes to fit education demands in the 21st century [2][5], and iii) provide learners with an opportunity to develop their creativity and communication skills [2]. On the other hand, the weak use of ICT on higher education systems can lead to a negative impact on educational outcomes [6].

Likewise, use of ICT in education enables supporting traditional ways of teaching today. An online course is one example that allows students to follow educational materials offered by their home university, or in another country or time zone [3].

Since the Internet revolution, several instructional technologies have been supporting higher education systems that are focused more on the impact of activities and use of educational platforms, for instance online labs. Today, online labs (both Remote and Virtual Labs) can support hands-on labs in many fields, especially in science and engineering, by facilitating learners to access more educational materials, resources, and costly equipment [7][8].

Having set the context, in general, the aim of this chapter is to present the background and motivation of this work, problem statement, research focus, research objectives, and the work done during this PhD. Therefore, Section 2 presents science and engineering education, its open challenges, and envisaged solutions in overall terms. Section 3, 4, and 5 describe the problem statements, research focus, and research objectives of this thesis, sequentially. Section 6 shows where the ideas come from. Study purpose of this thesis is in Section 7. Section 8 lists accomplishments and contributions directly related to this thesis. Section 9 provides an overview of the thesis organization. Finally, the chapter conclusion is in section 10.

1.2 SCIENCE AND ENGINEERING EDUCATION

In science and engineering fields, the experiments done in laboratory are considered an essential backbone to improve students' skills. In a hands-on laboratory, the students interact directly with the equipment by performing actions (e.g. manipulating with the hands, pressing buttons, and so on) and receiving their feedback results by visual, audio, odour, and tactile interfaces [9].

Nevertheless, these fields face several barriers today in the practical side, for instance limitation of time, safety constraints, lack of hands-on labs, large number of students compared to the scarcity of laboratory equipment. In addition, research collaboration across those fields has not developed enough in some of its sub-areas and topics [10]. Installing new laboratories at a given institution may solve some barriers, but there may be other challenges such as the equipment acquisition and maintenance costs. In addition, educational innovations based on the use of instructional technologies (e.g. online labs) have appeared to assist higher education systems and serve the students and teachers, specifically in science and engineering fields.

Integrating ICT in science and engineering education becomes a pressing need today [11]. Therefore, with hands-on labs scarcity, several online labs projects (e.g. VISIR[i], iLabs[ii], LabShare[iii]) have been developed. Overall, the interaction in online labs, which are located in other geographical areas, can be similar to that happening in hands-on labs. The only difference is that hands-on experiments must be performed physically by the student, during a given time schedule. In contrast, online experiments can be performed from anywhere, through the Internet, at anytime.

[i] http://openlabs.bth.se/electronics/index.php/en

[ii] http://icampus.mit.edu/projects/ilabs/

[iii] http://www.labshare.edu.au/

1.3 PROBLEM STATEMENT

Currently, several countries in the world still did not update their higher education systems with new technologies, particularly in sciences and engineering fields. MENA countries are usually included in that group. Indeed, it could be said that the MENA countries have made great strides in eradicating illiteracy and reducing gaps in education among the people, but they still need to develop their higher education systems [12], and are not in the high quality level yet [13].

Another challenge is to update the curricula and transparency of the MENA higher education systems, as stated in [12]:

> *"MENA countries can learn first-hand through the best practices of these other countries that transparency of higher education systems is critical to increasing the quality of higher education in the region." (pp.7)*

Reference [14] also identified other issues related to higher education systems in the MENA region that must be debated, one being the relation between the adoption of new technologies and the quality of education:

> *"One of these explanations is related to the heterogeneity of the education–growth relationship from one country to another. Another is related to the quality of education, including the capacity of workers to innovate or adopt new technologies." (pp.47)*

In sum, most of the MENA countries share several attributes such as language, culture, education systems, community service, etc. However, they still lack a strong collaboration and cooperation dimension, which would allow them to share experiences, ideas, resources, particularly in education and research. This problem may be one of the main reasons hindering the progress of the higher education systems in the MENA region [15].

1.4 RESEARCH FOCUS

The proposed PhD work addresses the evolution of the higher education systems in the MENA region and their challenges, which are associated with the use of instructional technologies (e.g. online labs), and the way higher education institutions, from this region, can associate themselves to existing and emerging online labs federations for supporting the acquisition of experimental skills by enrolled students.

The research focus is to identify the requirements for a common acceptance of online labs offering an interface able to engage both teachers and students of higher education in that world region. Consisting of an online labs federation located in European countries and one associated MENA country, is thought to be fundamental for the proposed PhD work. The evaluation part should report not only on the technological challenges/problems faced but also include feedback from all the involved stakeholders, i.e. researchers, teachers, and students. Therefore, the synthesis of the research focus proposed for this PhD work would be:

“How can instructional technologies be used to help modernizing higher education systems in the MENA region, specifically in science and engineering education? Are online labs a possible solution considering, in particular, their ability to promote the open access to (and sharing of) experimental resources, which are crucial to science and engineering education? Furthermore, will they facilitate collaborative and cooperative work among the MENA researchers?”

1.5 RESEARCH OBJECTIVES

The use of online labs in higher education institutions located in the MENA region countries is still quite unknown to the general research community working in this field. Although there are records of installations, experiences and projects located in or involving higher education institutions of that region, a broader survey is missing. This type of survey can be an initial and most useful step preceding the wide adoption of online labs in this region, as happened in large regions such as the United States, Europe, Australia, and India. All the previous contexts highlight the potential benefit of doing a similar survey in the MENA region, considering the cultural and educational links among the MENA countries. Such a survey would be a first step towards the creation of a community of practices and an online labs federation in this region. Therefore, the overall objectives of this PhD work are:

- ❖ Helping to characterize the higher education systems in the MENA region, especially in science and engineering fields.

- ❖ Determining the level of collaborative and cooperative work among MENA researchers in online labs.
- ❖ Installing a new online lab system, e.g. a Virtual Instrument Systems in Reality (VISIR) node, for the MENA universities, supporting their native language.
- ❖ Building a Community of Practice (CoP) around online labs in the MENA region for sharing resources and experiments.
- ❖ Suggesting the idea of an online labs federation, for example a VISIR federation for supporting the MENA universities.

1.6 WHERE DO IDEAS CAME FROM

In general, ideas came from several sources (e.g. papers, reports, and websites) that are focused on higher education systems in the MENA region. In order to provide a guide brainstorming for this study, this work was strategically aligned with six questions, based on the 5W's and the H ideas method [16][17]. Overall, several questions popped up in the author’s mind. The answers to these questions are considered the focus goal of this study, as shown in figure 1.1.

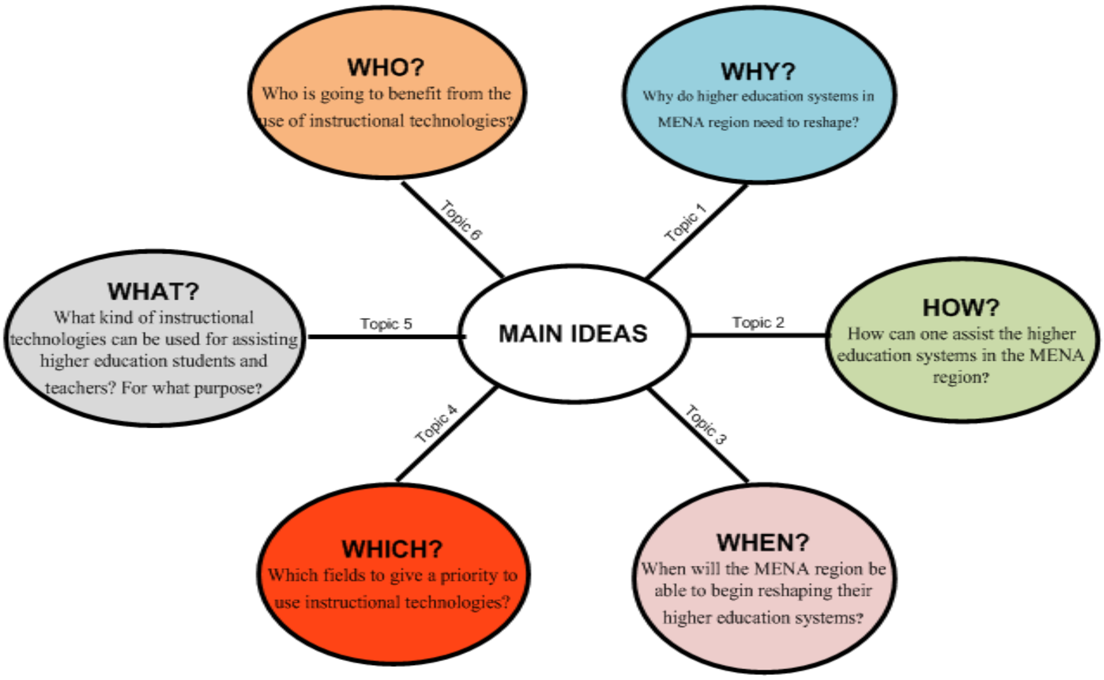


Figure 1.1: A Guide of Brainstorming Study "The 5W and the How Ideas"

- **Topic 1: Why do higher education systems in MENA region need to reshape?**

Based on used sources, the higher education systems in the MENA region are not improving as fast as they could, when compared with other regions. Therefore, it is possible to say there is plenty of room for improving the higher education systems in the MENA region, now.

- **Topic 2: How can one assist the higher education systems in the MENA region?**

More instructional technologies could be included into the higher education systems of the MENA region, such as online labs.

- **Topic 3: When will the MENA region be able to begin reshaping their higher education systems?**

With the increasing offer of instructional technologies, it is time for the MENA countries to improve their higher education system immediately, especially with tools, software, and other free applications, which are widely available now.

- **Topic 4: Which fields to give a priority to use instructional technologies?**

For increasing student and teacher qualifications in the MENA region, this study suggests using instructional technologies in science and engineering fields.

- **Topic 5: What kind of instructional technologies can be used for assisting higher education students and teachers? For what purpose?**

Online labs (i.e. VISIR) were selected for assisting the higher education students and teachers to develop their skills. In general, online labs can allow students and teachers to run and execute experiments from anywhere and at anytime. They can also support collaborative and cooperative work among researchers in this region as well. In general, VISIR is able to serve thousands of students from different countries and increase the collaborative and cooperative work among researchers, while sharing resources [18].

- **Topic 6: Who is going to benefit from the use of instructional technologies?**

In general, the future of higher education systems is determined by the development of technology for the education sphere. Several benefits can arise from the use of instructional technologies in the MENA region, for instance:

- Enhancing higher education systems.
- Helping universities to track students' progress.
- Making learning and teaching easier and more accessible to teachers and students than ever.
- Creating an enjoyable and interesting learning environment to students.
- Allowing access to information at any time, from anywhere, for both students and teachers.
- Making collaboration and cooperation more effective among researchers.

1.7 STUDY PURPOSE

The purposes of this study are:

- Equipping MENA universities with online labs for developing the experimental skills of their teachers and students. In this context, it means that online labs can be used to support hands-on labs, not to replace them.
- Raising the level of collaborative and cooperative work among MENA researchers.

1.8 ACCOMPLISHMENTS AND CONTRIBUTIONS

Several accomplishments and contributions have been achieved during the course of this PhD work. The journey involved research visits, participating in and assisting scientific international conferences, affiliation to scientific consortiums and interest groups, supervising international students, publishing contributions in international conferences, journals, a book chapter contribution, submitting a project proposal, managing groups, and reviewing conferences and journal papers. These activities can be summarized as follows:

1.8.1 PARTICIPATION AND PUBLICATIONS IN INTERNATIONAL CONFERENCES (Appendix 1)

❖ Participation and Presentation

i. R.M. Salah, “Remote Labs to improve Engineering Education in the MENA Region,” *International Conference on Engineering Education and Research (iCEER2013)*, 1-5 July 2013, Marrakesh, Morocco.

ii. R.M. Salah, G. R. Alves and P. Guerreiro, “Reshaping Higher Education Systems in the MENA Region: The Contribution of Remote and Virtual Labs,” *International Conference on Remote Engineering and Virtual Instrumentation (REV2014)*, 26-28 February 2014, Porto, Portugal. DOI: 10.1109/REV.2014.6784265.

iii. R.M. Salah, G. R. Alves, D.H. Abdulazeez, P. Guerreiro and I. Gustavsson, “Why VISIR? Proliferative Activities and Collaborative Work of VISIR System,” *International Conference on Education and New Learning Technologies (EDULEARN2015)*, 6-8 July 2015, Barcelona, Spain. ISBN: 978-84-606-8243-1.

iv. R.M. Salah, P. Guerreiro and G. R. Alves, “A Federation of Online Labs for Assisting Engineering and Science Education in the MENA Region,” *International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM2015)*, 7-9 October 2015, Porto, Portugal. DOI: 10.1145/2808580.2808680

v. R.M. Salah, G. R. Alves, B. Datkiewicz, P. Guerreiro and I. Gustavsson, ” VISIR System @ BTH, DEUSTO, ISEP, AND UNED Institutes: Assisting and Supporting Hands-on Laboratories to Serve Higher Education Students,” *International Conference of Education, Research and Innovation (iCERi2015)*, 16-18 November 2015, Seville, Spain. ISBN: 978-84-608-2657-6.

vi. J. Cecil, H. Richardson and R.M. Salah, "Cyber Learning Environments for Engineering Education," Frontiers in Education (FIE2017) conference, 18-21 October 2017, Indianapolis, Indiana, USA. (Accepted Abstract)

❖ Participation (only)

i. The IEEE Next Generation Networks and Services (NGNs) Conference, 2-4 December 2012, Faro, Portugal.

ii. The IEEE Global Engineering Education Conference (EDUCON), 13-15 March 2013, Berlin, Germany.

iii. International Conference on Remote Engineering and Virtual Instrumentation (REV), 24 - 26 February 2016, Madrid, Spain.

1.8.2 JOURNAL ARTICLES (Appendix 1)

i. R.M. Salah, G. R. Alves and P. Guerreiro, "IT-Based Education with Online Labs in the MENA Region: Profiling the Research Community," International Journal of Human Capital and Information Technology Professionals (IJHCITP), Volume 6, Issue 4, Pages 1-21, 1 October 2015. DOI: 10.4018/IJHCITP.2015100101 [SJR 2015 Impact Factor 0.26][i] [Q2 Computer Science (miscellaneous)]

ii. R.M. Salah, G. R. Alves, P. Guerreiro and I. Gustavsson, "Using UML Models to Describe the VISIR System," International Journal of Online Engineering (iJOE), Volume 12, Issue 6, Pages 34-42, 30 June 2016. DOI: 10.3991/ijoe.v12i06.5707 [SJR 2015 Impact Factor 0.228][ii] [Q2 Engineering (miscellaneous)]

---

[i] http://www.scimagojr.com/journalsearch.php?q=21100223336&tip=sid

[ii] http://www.scimagojr.com/journalsearch.php?q=20000195073&tip=sid&clean=0

1.8.3 BOOK CHAPTER (Appendix 1)

i. R.M. Salah, G. R. Alves, S. K. Talal, C. Viegas and P. Guerreiro, ”A Community of Practice Around Online Labs in Iraq: Towards Effective Support for Academics and Educational Systems in the MENA Region,” in Higher Education Edition Book, Susan (Sue) L. Rene Editor, University of Alaska Fairbanks, Fairbanks, Alaska, USA, 2017. Accepted[i]

1.8.4 RESEARCH PROJECT

i. Leader of the “Building a Remote Experimentation Network for serving higher education teachers and students in Iraq” (REXNet) Project[ii], which is supported by the United States International Research & Exchanges Board (IREX). This project is a collaboration between the Oklahoma State University (OSU) and three universities in the Kurdistan Region of Iraq, namely University of Duhok (UoD), University of Zakho (UoZ), and Duhok Polytechnic University (DPU). In general, it aims to use Virtual Labs for serving students and teachers of computer sciences from those three universities.

1.8.5 OTHER ACTIVITIES

i. Member of the VISIR Special Interest Group (SIG)

ii. Member of the IEEE-SA P1876 WG

iii. Admin of the VISIR Activities Group in Mendeley platform[iii].

iv. Served in the organization of the following international conferences:

---

[i] http://www.intechopen.com/welcome/98977ad0f9bc0a5224a23d6f67b343ca

[ii] https://tinyurl.com/jtf96m3

[iii] https://www.mendeley.com/groups/6702311/visir-sig-researchers-and-contributions/

- The IEEE Next Generation Networks and Services (NGNSs) Conference, 2-4 December 2012, Faro, Portugal.
- International Conference on Engineering Education and Research (iCEER2013), 1-5July 2013, Marrakesh, Morocco.
- International Conference on Remote Engineering and Virtual Instrumentation (REV), 26-28 February 2014, Porto, Portugal.

v. Served as a reviewer in the following international conferences and journal.

- International Conference on Remote Engineering and Virtual Instrumentation (REV), 2014, Porto, Portugal.
- Information Technology & People Journal (ITP), 2015.
- International Conference on Remote Engineering and Virtual Instrumentation (REV), 2016. Madrid, Spain.

vi. Supervised two Erasmus students. First one was an MSc student from Poland, from July 7 to September 7, 2015. Another was a senior student from the Netherlands, from February 8 to July 8, 2016.

vii. Evaluated online experiments of the REXLab[i] group

viii. Update the VISIR User Interface source code in order to support two additional languages (Arabic and Kurdish). This new version is installed in the new VISIR @ ISEP node. http://svn.openlabs.bth.se/trac/openlabsweb/changeset/450

[i] http://relle.ufsc.br/

1.9 THESIS ORGANIZATION AND OUTLINE

As shown in figure 1.2, this thesis is organized into three parts. First part includes three chapters: One, Two, and Three. Second part also includes three chapters: Four, Five, and Six. Third part includes two chapters: Seven and Eight.

- **Part I: Contextualization, Analysis of Requirements, and Planification**

  This part allows contextualizing the PhD work and making things simple to follow as possible. Initially, the scope and the appropriate methods must be determined, as well as the various tasks necessary to complete the work. Furthermore, the chapters in this part allow defining a roadmap for this thesis and specific directions to complete the proposed objectives.

- **Part II: Implementation and Convincement**

  This part explains how the ideas defended in this PhD work were implemented. Coming together, this part combines technology, education and social constructivism. Specifically, it includes three thematic directions related to online labs: one system, one community, and one federation. The first chapter shows how the installation of a new VISIR node can support countries in the MENA region. The second chapter focuses on social learning as a Community. It shows how a community, which is based on researchers, can work as a team around online labs, for supporting higher education systems. The third chapter presents the idea of an online labs federation (i.e. VISIR federation) and shows how such a federation may assist the higher education systems of those countries.

- **Part III: Evaluation and Conclusion**

  This part evaluates the work done and describes some ongoing activities. It provides an overall appreciation of the work done, by presenting the obtained results and highlighting their validation. Furthermore, it presents the conclusion and future working directions. It also lists several recommendations for other researchers on how to continuously develop higher education systems in the MENA region.

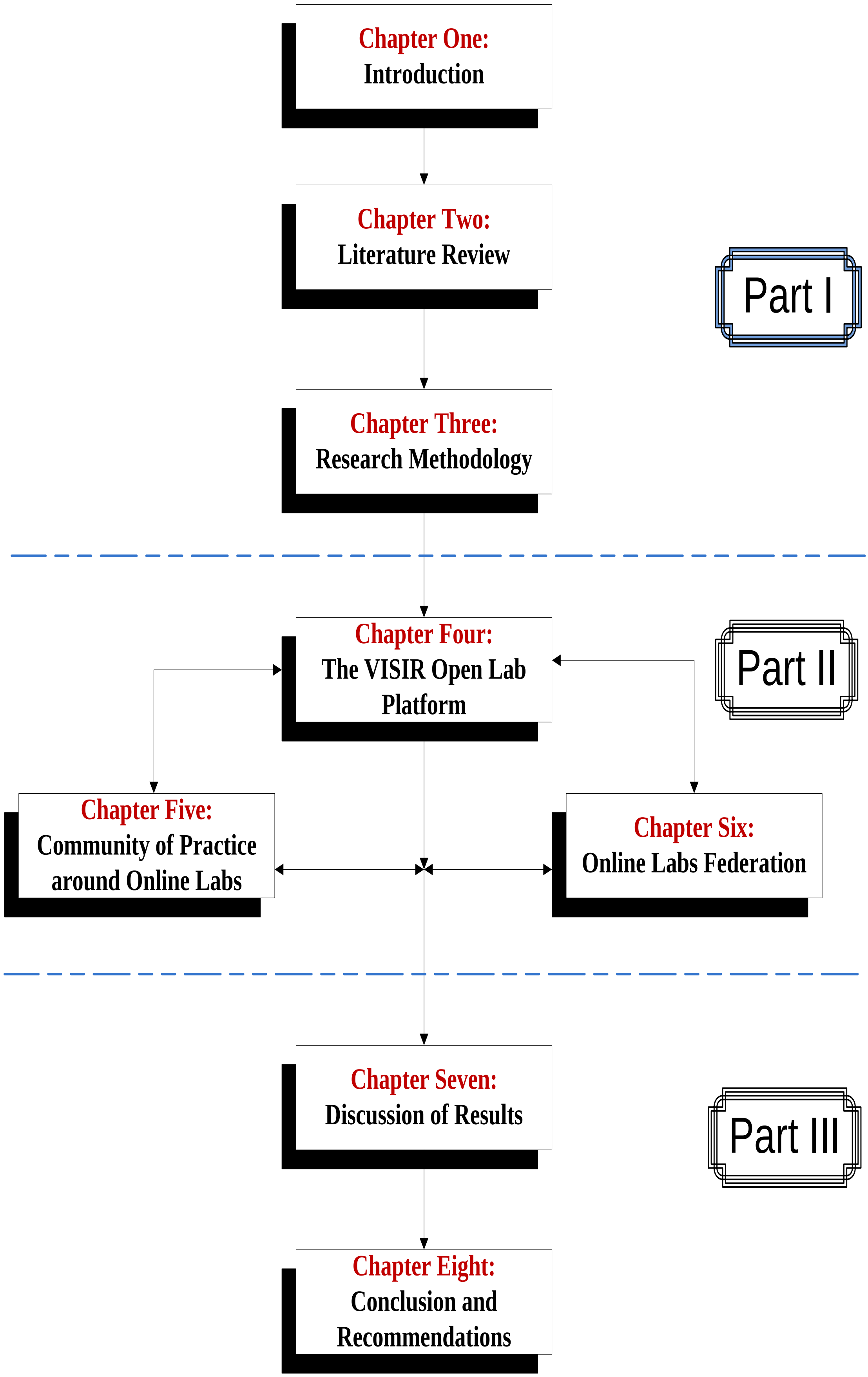


Figure 1.2: Thesis Scaffolding

Each of the remaining thesis chapters may be summarized as follows:

- **Chapter 2: Literature Review**

This chapter provides a systematic literature review in order to:

- Generally, introduce higher education systems in the MENA region, in general.
- Explain how instructional technologies (i.e. online labs) can support and benefit the teaching and learning processes.
- Show the impact of online labs on education and institutions.
- Provide several examples of online labs.
- Explain how online labs can increase collaborative and cooperative work among researchers.

- **Chapter 3: Research Methodology**

This chapter addresses the research methodology, in particular the research design, data collection, and data analysis phases, followed in this study. In addition, it shows the study directions.

- **Chapter 4: The VISIR Open Lab Platform**

This chapter introduces a new VISIR node, which was installed at Instituto Superior de Engenharia do Porto, the engineering school of Porto Polytechnic (IPP-ISEP), in Portugal, for assisting a selected number of higher education institutions located in the MENA region. The main objective of this node is to assist teachers and students gaining more practical skills and increase collaborative and cooperative work among researchers in this region, especially in science and engineering fields.

- **Chapter 5: Community of Practice Around Online labs**

This chapter provides the idea of communities of practice in education. It shows the principle and benefits of having a community of practice around online labs in the MENA region. This chapter also highlights what a community of practice can achieve by working together.

- **Chapter 6: Online labs Federation**

This chapter illustrates the idea of a VISIR federation and shows how this federation can assist students and teachers, by balancing experiments among VISIR nodes. Overall, this chapter proposes a scenario for a VISIR federation, and the short, medium, and long-term outcomes.

- **Chapter 7: Discussion of Results**

This chapter presents the results and discusses their validity. It also discusses the expected impact of this work.

- **Chapter 8: Conclusion and Recommendations**

This chapter concludes the work with some recommendations for other researchers interested in working in the online labs area, especially from the MENA region.

1.10 CONCLUSION

Developed regions like Europe, the United States, Japan and Australia have invested in instructional technologies such as online (remote and virtual) labs. The use of online labs becomes a complement to hands-on labs classes in these developed regions.

At the opposite end, other regions (like MENA) have the financial resources to invest largely in their higher education systems, but they lack both the human and technical infrastructures for graduating such a huge number of students in the immediate term. An alternative solution is to invest in technology-enhanced learning tools and/or Learning Management Systems, e.g. MOOCs. They are now rapidly growing in a global context, but, again, the acquisition of experimental skills needs to be carefully addressed and the solution comes in the form of on-campus weeks for doing the practical, laboratory-based component or, once again, through the use of online labs.

Currently, online labs have become a "commodity", and, just like other types of computerized systems, they are available 24/4, allowing students and teachers to perform experiments via the Internet, whenever they need. Therefore, they are considered a good instructional technology for developing experimental skills, providing highly flexible online experiments, as in hands-on labs, and allowing researchers to establish a strong collaborative and cooperative work among them and with others worldwide.

In this context, this thesis focuses on how can higher education systems in the MENA region be enhanced, and how can the teachers and students of this region get a good quality education. One of the most common approaches is to integrate online labs, for example VISIR, into their higher education systems for providing access to more experimental resources and educational materials in a flexible way. Furthermore, online labs can raise higher education quality of science and engineering fields in the MENA countries and assist their researchers for working together around this research topic.

"Following the light of the sun, we left the old world"

Christopher Columbus (1451-1506)

CHAPTER 2.

LITERATURE REVIEW

Abstract

Every year, a worldwide country-level ranking and classification list of higher education institutions is published in the Internet. An important point in this list is that there are no institutions from the MENA region ranked in top-level positions, at least in the last decades. A possible reading is that higher education systems in this region still did not develop worthily and still need to expand themselves for the better. As a result, this situation leads to disparate impact and complex education systems and few linkages among the MENA region educators. Today, the emergence of online learning allows teachers and students to personalize education in ways that were impossible in the past. Furthermore, interactive technologies, such as online labs, can support higher education systems in many countries worldwide, especially in the MENA region countries. Existing literature provides evidence that online labs can assist and enhance education systems and increase collaborative and cooperative work among their teachers and students.

2.1 INTRODUCTION

Recently, most people think of learning as what one does at schools or universities, i.e. just study for testing. Nowadays, several learning styles have been identified, for instance Visual *"using image or picture"*, Aural *"Using sound and music"*, Physical *"using body and hand"*, Social *"learning as groups or with other people"*, etc. Understanding these styles has allowed to improve teaching methods and to influence the development of new instructional technologies, especially for STEM disciplines [19].

In parallel, several developed countries have started to improve their higher education systems by including instructional technologies to increase collaborative and cooperative work among researchers, especially in science and engineering fields. This development has been supporting government's economy and opening many academic programs that rely on research, for example in the United States and Europe [20]. On the other hand, other countries, like those from the MENA region, have not reshaped their higher education systems to match the needs and challenges of the twenty-first century. In sum, their education systems became too complex and took disparate forms [13]. This may explain why the MENA region has not the ability to deliver the needed knowledge and technology to students and teachers as other regions [21], especially in science and engineering disciplines, according to the Arab economic and social summit.

Nowadays, ICT are integrated in several education domains and their use has become commonplace. Many countries have used ICT effectively to improve and develop curricula and educational system quality, and deliver quality learning and teaching to teachers and students [4][22]. ICT are being successfully integrated into education systems through multimedia, e-learning, and distance education, etc. [23][24].

Currently, according to several papers [25], online learning is considered a newer and improved version of distance learning. It can include resources and courses that are available online and it allows learners to access them, through the Internet.

In general, hands-on labs play a central role in scientific education in science and engineering disciplines. They provide learning opportunities to students through the use of real equipment, which are located in the physical laboratory and under teacher supervision [26]. Years ago, hands-on labs were the only type of labs available to students. Therefore, they faced some challenges, for instance providing flexible access to real equipment 24/7 to students and increasing students' numbers [27].

A few years ago, the idea of using online labs for assisting hands-on labs has grown. In general, online labs are based on lab experiments that can be delivered via the Internet efficiently, with lower cost, and from anywhere and anytime. However, they exist for assisting hands-on labs, not to replace them [28].

Likewise, online labs allow students to access equipment, individually or with other students located in geographical distant places, especially equipment for science and engineering disciplines that are considered rare and expensive [29][30].

Froyd et al. [11] indicated the five major shifts in engineering education that have occurred during the past 100 years. One of those major shifts was integrating information, computational, and communications technology in education systems by including the most relevant instructional technologies and applications, for instance online labs and computational technologies. Therefore, MENA countries need to integrate several technologies (i.e. online learning and online labs) in curricula for enhancing their educational system, especially in science and engineering disciplines.

It should be said, at this point, that the present study will follow a systematic literature review to evaluate and interpret available research evidence that is relevant to a particular research question, topic area, or interesting phenomenon related to the study. In addition, it explains how to investigate a specific research question and interpret all available research evidence related to the research question, and then identify a well-defined methodology [31][32]. Therefore, the stages of this study are [33][34]:

- ❖ Planning the review: identification of the need for a review and specifying the research question.
- ❖ Conducting the review: identification of research and data synthesis.
- ❖ Reporting the review: specifying dissemination mechanism, formatting and evaluating the report.

This chapter is organized as follows: section 2 briefly introduces the higher education systems in the MENA region. Section 3 explains technology-enhanced education and also instructional technologies that support learning, such as online labs. Section 4 presents online labs in more detail and provides different online labs examples. Section 5 presents the idea of increasing collaborative and cooperative work among researchers by using online labs. Conclusion is given in Section 6.

2.2 HIGHER EDUCATION SYSTEMS IN THE MENA REGION

Currently, higher education systems are based on teaching and learning knowledge, awareness, and implications. In many countries, students' performance is considered as an indicator to the quality of higher education systems. A number of developments have taken place in higher education systems worldwide to encourage students enhancing their experiences and skills, and developing flexible study habits. In particular, policies have been created to curb student retention and to help students for completing their study in the prescribe period of time. Therefore, as an example, European countries have started to reshape and modernize their education systems by incrementing bridging programs and increasing exchanges among institutions [35].

Other countries, such as the countries from the MENA region, still face a set of challenges in developing their higher education systems [36]. Indeed, they have been following a different path from that Europe or the United States followed for developing their higher education systems or they did not find alternatives for developing their education systems [21]. This means that MENA countries continued to follow the traditional model of science and engineering education [37], still not using instructional technologies significantly. In result, for enhancing their teaching and learning processes, they must offer more instructional technologies to teachers and students in the fields of science and engineering [38] that can face challenges and have an effect on human capital formation in the MENA region [39].

Today, knowledge and technical skills have become critical factors to economic growth for many developed countries. In fact, on average, about 70%, of the students in the MENA region follow humanities and arts studies, i.e. more than engineering and technology. This percentage is considered high, when compared to other regions (i.e. East Asia and Latin America) [39].

Recently, several organization programs are available for supporting higher education in the MENA region, for instance IIE[i] and IREX[ii]. These programs aim to extend and share with MENA countries information and resources, knowledge, and quality education that are available in developed countries. They focus on bringing expertise and experience in education fields to the MENA region by allowing partners to work at the MENA institutions and investing in human potential. In result, these programs have been serving thousands of students, scholars, and professionals from the MENA region, each year [40].

Other substantial opportunities, namely scholarship programs, are available for the MENA region (e.g. Fulbright[iii], MSP[iv], and Erasmus Mundus[v]). These programs offer scholarships, for short and long courses, to students and teachers from the MENA countries for increasing mutual understanding between the MENA and other developed countries (i.e. United States and European Union).

In recent years, many international universities have opened branches in the MENA countries (e.g. the United Arab Emirates, Qatar, and Saudi Arabia). These branches have had an impact on supporting local education systems and curricula development by sharing new teaching methods [41].

Nevertheless, with those scholarships, organization programs, and international universities branches in the MENA countries, higher education systems in this region still have not developed more and have not focused on twenty-first century skills [12][42]. Shortly, they still face several main challenges, especially in STEM fields, such as inequalities, reduced use of technologies in course curriculae, lack of connection and interaction between MENA universities, and few connections among MENA researchers for sharing sources and knowledge [21].

---

[i] http://www.iie.org/

[ii] https://www.irex.org/

[iii] http://www.cies.org/region/middle-east-and-north-africa

[iv] https://www.studyinholland.nl/scholarships/highlighted-scholarships/mena-scholarship-programme

[v] http://www.usc.es/marhaba/

Nowadays, several resources and studies have evaluated higher education system in the MENA region and showed achievements and challenges that exist in the MENA region. For example, in 2014 the World Bank published an online report related to education systems in the MENA region. It mentioned that the MENA region has taken great strides and achieved several results in education. On the other hand, it listed several challenges that are still faced by the MENA education, for instance educational quality and students' skills [43], as stated:

> *"Educational quality: Evidence demonstrates that school systems in MENA are generally of low quality. Basic skills are not being learnt, a fact most clearly captured by international standardized tests, whose results reveal that the Region is still below the level expected given MENA countries' per capita income."*

In May 2015, Al-Masri wrote an online article about education systems in the MENA region, specifically the Middle East. He states that the education system in Middle East must be updated for growing and increasing students' skills [44].

In 2015, at the British Council website, Philip Powell-Davies wrote an online article about the MENA education as well [45], where he mentions the following:

> *"Significant and growing numbers of young people across the Middle East and North Africa (MENA) are being inadequately educated and are emerging from education systems with little or no employment prospects as a result of poor teaching, antiquated curricula and a lack of practical skills both hard and soft."*

> *"Basic schooling that is taken for granted elsewhere is falling short. Education systems struggle to attract and retain good teaching staff and use out-dated pedagogies with traditional models of learning, which leave students poorly equipped to function in more modern knowledge-based economies."*

Powell-Davies points out that improvements in education quality are accompanied by increasing the capabilities of technical skills can show better outcomes. In addition, there are components that can help improve education quality, for instance technology-based educational resources, which are considered a main component for successful outcomes in education.

Furthermore, Bhandari and El-Amine classified higher education institutions in the MENA region [12]. Overall, they said:

> *"While the number of global and country-level ranking and classification systems continues to expand, a regional classification and assessment of higher education institutions in the Middle East and North Africa (MENA) region has not been developed. Such a system is particularly needed given the rapid expansion of the higher education sector in the region, as new domestic institutions and branch campuses of overseas institutions emerge. As a result, higher education in the Arab countries nowadays is complex and takes disparate forms."(pp.5)*

As well, they mentioned there are limitations to networking and cooperating among the MENA institutions, as stated:

> *"At the institutional level: The lack of a classification scheme for HEIs in the Arab region also limits the prospects of networking, exchange, mobility, and cooperation between institutions, in the region and abroad, of similar profiles and characteristics."(pp.5)*

Additionally, Bhandari and El-Amine concluded their work by mentioning the higher education systems in the MENA countries have rapidly changed and expanded but, essentially, the MENA countries must scale up their educational system for high-level classifications.

The World Innovation Summit for Education (WISE) [46], which was established by the Qatar Foundation in 2009, surveyed education systems around the world in 2015. This recent study focused on how well education systems around the world prepare students for working in their fields. Overall, WISE divided the world according to regions (e.g. East Asia, South Asia, Southern Asia, Balkans/former Soviet Union, Europe, Latin America, MENA, United States/Canada/Australia/New Zealand, and Sub-Saharan Africa). This survey mentioned the education systems around the world are varying greatly from region to region. In result, they included the MENA region as one of regions that face huge challenges in reforming their education systems.

One point in this study, which is related to how can universities find a job for their students, was that WISE believed some regions, for example the MENA region, are not doing enough to prepare students for the workplace and not taking advantage of the opportunities offered by new technologies, as mentioned by Alan Krueger [46]:

> *"The 2015 WISE education survey provides clear evidence that education systems around the world are not doing enough to prepare students for the workplace. Experts from around the world voice clear concerns that the education systems in their countries are insufficiently innovative. The irony is that at a time when technological change is rapidly changing the world of work, the education systems in many countries are failing to innovate and take full advantage of the opportunities offered by new technologies." (pp.29)*

2.3 TECHNOLOGY-ENHANCED EDUCATION

The Internet and ICT have become a fundament and an infrastructure of online learning worldwide. They have improved education and learning experience quality of many universities worldwide by offering information and educational resources to their students [47]. Since the beginning of this century, education systems, teachers, and researchers have been affected by ICT [48]. Nowadays, ICT has become the core of education and one of the fastest growing trends in educational uses of technology [49].

According to Noor-Ul-Amin [4], in the educative process, ICT is divided into two categories: ICT for Education *"refers to the development of information and communications technology specifically for teaching/learning purposes"* and ICT in Education *"involves the adoption of general components of information and communication technologies in the teaching learning process"*.

Using ICT in the educative process can enhance teachers and students knowledge, skills, and experience by providing several activity learning opportunities (e.g. online learning and online labs), as stated [40]:

> *"..... technology transfers some responsibility for learning to students. Through online learning (which provides increased access to course content, more scheduling flexibility, and better access to alternative*

> *education choices) and alternative media (such as digital games and project-based learning), students have the flexibility to direct their individual progress."(pp.6)*

> *"..... the use of this online learning environment can result in improved outcomes for students in areas including critical thinking, creativity, teamwork, cross cultural understanding, communication, technology skills, and self-direction ....." (pp. 31)*

Nix et al. [50] mentioned that it is the ICT era that can support educational system for enhancing teachers and students. As he cited the words of David Thornburg in 2000:

> *"We are on the cusp of a completely new era and changes must be made in education to ensure that all students leave school prepared to face the challenges of a redefined world" (pp.55)*

Nowadays, the rapid development of ICT has been allowing teachers and students to learn and extract information from anywhere, at anytime, from the Internet. Currently, several platforms, which are supported by ICT, are available and accessible over the Internet for creating online courses. These platforms are aimed to provide a collection of online courses in many different fields, for teachers and students. A recent one is named Massive Open Online Course (MOOC)[i]. Therefore, for serving educational system and learners one must take full advantage of opportunities offered by ICT [51]. Likewise, other current trends of technologies (e.g. simulation, remote and virtual labs) that are supported by ICT have been applied and integrated into education systems, especially in science and engineering domains [52][53][54].

Today, instructional technologies, such as online labs, have become a solution to universities, particular in developed countries, for improving higher education systems and increasing the students' skills in different fields. In general, online labs can improve education by offering opportunities to teachers and students for accessing experiments

---

[i] http://mooc.org/

via the Internet [55]. It is considered as a more recent version of distance learning [25] and a fastest growing trend in educational uses of technology [55].

In brief, online labs refer to the instructional environments that are supported by the Internet and a wide variety of programs for providing access to materials and creating interaction between teacher and student [56][57].

Consequently and evidently, online learning has become required to support higher education systems and learners. Therefore, several universities, which are dependent on distance learning, have opened around the world (e.g. Open University in the Netherlands[i], UK, National[ii] Distance Learning University in Spain[iii], and Arab Open University in Middle East[iv]). In general, online learning can provide teachers and students with the opportunity to learn online courses and subjects, from anywhere and at anytime, via the Internet [47][56]. It refers to courses and subjects in which at least 80 percent of the course content is delivered online [58]. Currently, learners can find several websites offering online courses, from top universities and other educational organizations (e.g. Coursera[v], edX[vi], and khan Academy[vii]) and they can enrol to these online courses from different fields, specifically humanities, social science, education and computer science, and engineering, in a clear and accessible way and with full information, details, and materials [59][60].

At the present period of time, software applications support education systems by providing a comprehensive set of tools for educators to manage resources and assessments via the Internet and they have been increasing student's skills especially in

---

[i] https://www.ou.nl/web/open-universiteit

[ii] http://www.open.ac.uk/

[iii] http://portal.uned.es/portal/page?_pageid=93,25451643&_dad=portal&_schema=PORTAL

[iv] https://arabou.edu.kw/

[v] https://www.coursera.org/

[vi] https://www.edx.org/

[vii] https://www.khanacademy.org/

STEM fields. Various universities use these applications, namely Learning Management System (LMS), over the world [61].

Several platforms are available as free open source software or commercial software [21][61][62]. They are used for delivering online courses to learners and allow them to interact and collaborate out of classroom as well [61][63][64], as in the case of the MOOC courses, mentioned above [65][66]. Currently, one can find a large number of online courses, in many fields which are offered by universities around the world and integrated with LMS and open course platform [67].

2.4 ONLINE LABS

Nowadays, teaching methods have evolved from traditional to newest ones by including instructional technologies. They have allowed students to interact and to be encouraged for acquiring results in their study field [68].

Teachers have increasingly searched for efficient ways to provide additional times in hands-on labs to their students. They have included several instructional technologies in education systems for overcoming obstacles such as limited access to laboratories and costly equipment, especially in STEM disciplines [69].

The widespread availability of the Internet and web access has enabled many useful instructional technologies, for example online labs, to serve STEM areas. In general, online labs are a technology that enables teachers and students to execute experiments via the Internet 24/7 [70][71]. For the last two decades, online labs have gained significant attention from many researchers and educators, by publishing research papers and using them in their institutions [72].

Certainly, deploying online labs in an educational environment presents several advantages, such as providing more opportunities for students to perform experiments without time and place restrictions, increasing access to particularly expensive equipment, etc. [67][71][73][74].

Generally, online labs are a synonym of Virtual and Remote Labs [75]. Virtual Labs are based on a software visualization that is a simulation, as realistic as possible, of hands-on labs. Remote labs are based on real devices that are located in physical labs or somewhere else, and accessed through the Internet [9][26][9][76][77].

2.4.1 VIRTUAL LABS

Virtual Labs enable teachers, researchers, and students, who are located around the world, to work together by providing online access to labs in various disciplines [78], as defined [79].

> *"A virtual laboratory is one where the student interacts with an experiment or activity which is intrinsically remote from the student or which has no immediate physical reality" (pp.1)*

Furthermore, virtual labs can provide an opportunity to teachers and students to learn and develop their practical skills in various fields, as said in [80]:

> *"Virtual laboratories provide an opportunity to the students to learn and practice at their own pace. To create online interactive media which would help students learn difficult concepts in various domains." (pp.1)*

In general, the architecture of a virtual lab involves a computer server, which usually hosts a collection of simulated experiments. Shortly, students can perform actions, remotely, from their own computer by sending input over a network to the computer server. Afterwards, the computer server sends feedback directly to students over a network [81], as shown in figure 2.1.

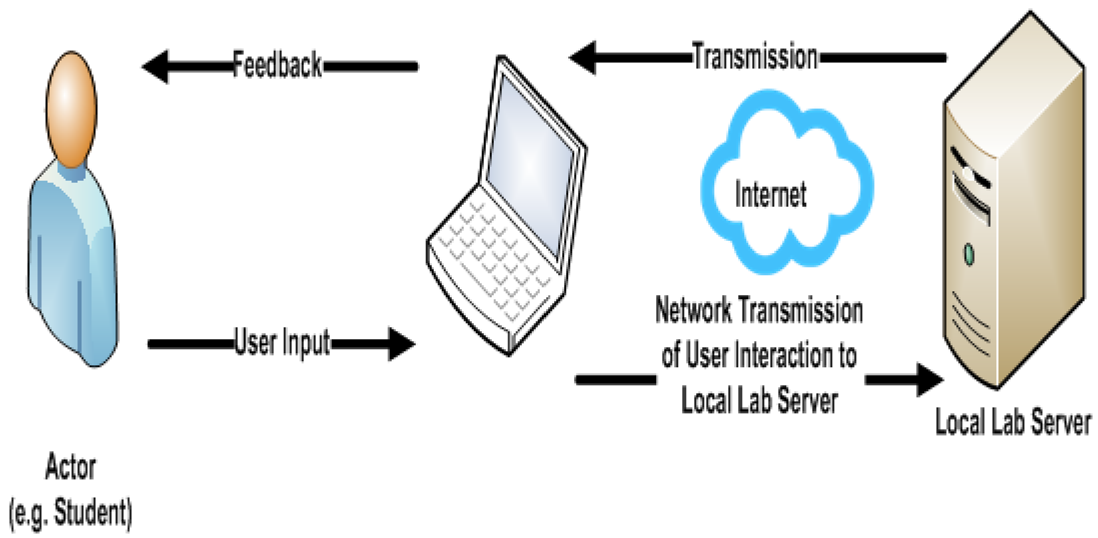


Figure 2.1: Virtual Labs Architecture (As taken from Reference [81])

2.4.2 REMOTE LABS

Remote labs are interactive environments that connect with real equipments, at some physical location and in real-time, via the Internet [82][83][84]. They allow teachers and students to control and run experiments without time and location restrictions, as said in [83]:

> *"Remote laboratories (also know under different aliases) can provide remote access to experiments (and to simulators as well), and can allow students to access experiments without time and location restrictions." (pp.10)*

In general, the architecture of a remote lab involves a computer server that is connected to real equipment. Shortly, students are connected by a personal computer to the Internet and perform actions by utilizing specific software remotely. Naturally, each input by the student is received by the local lab server, which transmits it over the Internet to the computer server that is directly connected with real equipment to perform some action. Afterwards, the computer server sends to the student the feedback it receives from the equipment, using the same network [85], as shown in figure 2.2.

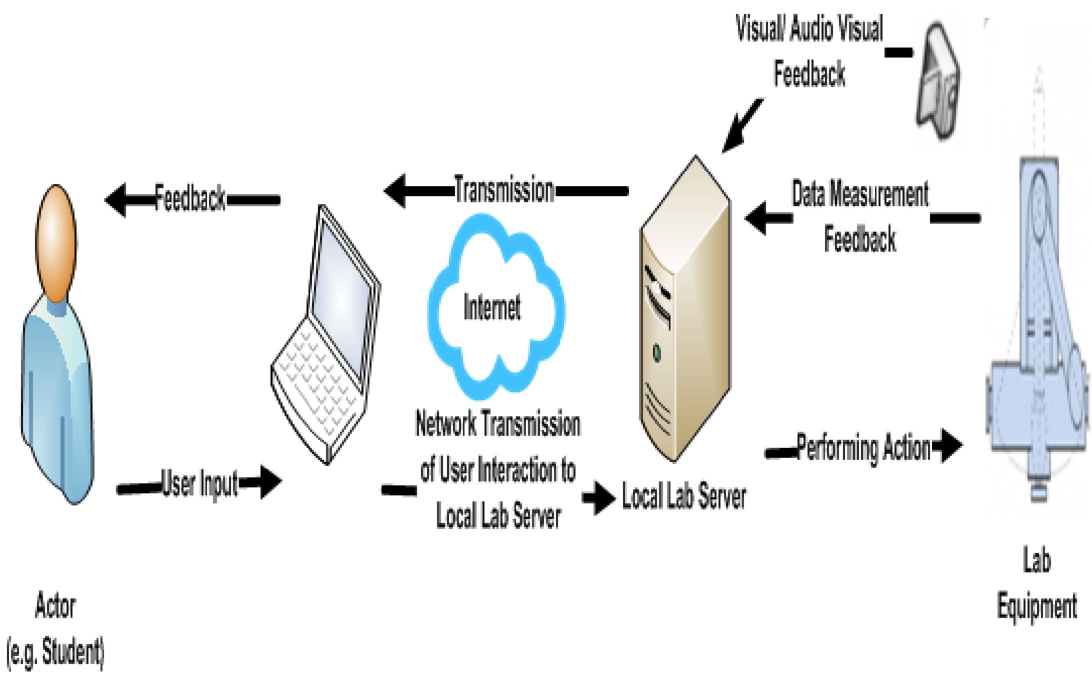


Figure 2.2: Remote Labs Architecture (As taken from Reference [85])

2.4.3 ONLINE LABS EXAMPLES

Today, online labs are in the centre of different initiatives such as: (i) integration in specific platforms (e.g. iLab and WebLab-Deusto); (ii) projects for disseminating their use (e.g. Go-lab and Lab2go); (iii) LMS (e.g. Moodle); and (iv) online courses platform (e.g. MOOC) [70].

Likewise, one can find a wide range of online experiments -*Remote and Virtual experiments*- that are available over the Internet in different STEM fields. They can be part of: the result of a project, or a repository, or platform to locate educational online labs experiments. Some of them have been developed by a single of institution or by group of institutions, for example:

- **Virtual Lab Development Project**

  It was developed by a group of institutions from India. It is considered one of the largest educational initiatives in the world. Today, it includes more than 205 online labs, +1515 online experiments, in multiple disciplines. This project has several partners and it provides remote access to experiments for their students and teachers from different educational levels. (http://virtual-labs.ac.in/) and (http://www.vlab.co.in/)

- **NMSU Project**

  It has been developed by three collaborating universities, namely North Dakota State University, New Mexico State University, and South Dakota State University, from United States. It aims to help students learning basic laboratory techniques and practice methods in a variety of food science labs. (http://virtuallabs.nmsu.edu/)

- **Learn.Genetic Project**

  It has been developed by the Genetic Science Learning Center at the University of Utah. It focuses on science fields, specifically genetic science, by allowing students to run experiments over the Internet. (http://learn.genetics.utah.edu/content/labs/)

- **VISIR Open Labs Project**

It is an electronics laboratory developed by the Blekinge Institute of Technology (BTH), in Sweden. It plays an important role in electrical and electronic engineering study by offering remote experiments with real components via the Internet. Currently, it has been serving thousands of students from different countries. (http://openlabs.bth.se/electronics/index.php/en)

- **LILA Consortium Project**

It is an initiative of eight universities and three enterprises. It aims to exchange online labs through a specific portal which grants access to the experiments via the Internet. In addition, this portal includes several services such as a scheduling system, connection to library resources, tutoring system, and 3D-environment for online collaboration. Furthermore, LiLa has created a framework to exchange experiments among institutions for collaborating teachers and students to access and setup these experiments, especially in science and engineering fields. (http://www.lila-project.org/)

- **Labshare Sahara Consortium Project**

It has been supported and funded by the Australian Government. It aims to share laboratory resources and create a national network of remotely accessible laboratories within the education sector. In addition, it includes a number of high-quality laboratories that are based on educational experiments. These online experiments are available to students from Australia and abroad, from anywhere. (http://www.labshare.edu.au)

- **Go-Lab Repository**

It is a repository that includes various remote and virtual labs from different institutions worldwide. Go-Lab aims to support students and teachers by offering a wide range of online labs in a virtual environment. In addition, it has many partners from European universities. Currently, this project has integrated a MOOC for offering online courses to teachers and students remotely. (http://www.go-lab-project.eu/)

- **WebLab-Deusto Platform**

It is an initiative of the University of Deusto, in Spain. It aims to increase online experiments for allowing students of universities and secondary schools from different countries worldwide to run them remotely and for multiple research projects. Currently, this project includes several free remote lab experiments, especially in engineering fields, such as Robot, FPGA, CPLD, and Logic Gates experiments. (http://weblab.deusto.es/website/)

- **iLab Platform**

It is a remote lab that provides access to real equipments through the Internet. It supports enriched science and engineering study by expanding the range of experiments available to students in the course of their education. iLab aims to share remote experiments with other universities around the world, within higher education, and to create a set of experiment resources that make experiments easier for sharing and collaborating among teachers and students. Furthermore, it has developed software tools for managing lab experiments, namely the iLab Shared Architecture (ISA). Nowadays, iLabs has several partners, from Europe, India, China, Australia, United States, and Africa that use iLab experiments via the Internet.
(https://wikis.mit.edu/confluence/display/ILAB2/about+iLabs)

2.5 COLLABORATIVE AND COOPERATIVE WORK

The expression “collaboration and cooperation” can mean several things, such as interdepartmental communication, partnership working, two or more organizations working together, etc. This section clarifies the meaning of collaborative and cooperative work, using instructional technologies.

Collaborative and cooperative work means that two or more persons, often groups, work together for sharing ideas to accomplish a common goal. Nowadays, with advancing technologies such as web programs, file sharing, and video-conferencing, collaborative and cooperative work has become a more productive way for serving education systems. Collaborative and cooperative work can provide solutions for common problems by bringing together groups, especially people with different perspectives and expertise. As a result, collaborative and cooperative work helps to develop learners' skills through sharing knowledge, ideas, and working together, and allow them to come up with faster ideas and solutions efficiently [86].

Today, education needs technologies for supporting collaborative and cooperative work among teachers and students. Several technologies are being used for this, for instance online labs. Even now, online labs have proven to be good platforms for teachers and students to increase collaborative and cooperative work and to develop their practical skills, especially in science and engineering education [74][87][88], as stated by Nafalski et al. [87]:

> *"Remote or virtual laboratories become a reality in engineering education as augmented traditional laboratories. The students in them have a central part in the learning process and can use grid technologies as a collaborative environment" (pp.2)*

Likewise, Müller and Erbe believed that remote labs are a valuable technology for sharing resources among teachers and students, and ideal tools for teaching collaboration and cooperation skills, especially in science and engineering fields, as stated in [89]:

> *"We believe that remote laboratories are ideal tools for teaching distributed collaborative work skills, because they offer perspectives of shaping teaching scenarios which are close to real distributed engineering team work." (pp.1)*

According to Fakas et al. [90], collaboration and cooperation are considered essential ingredients for creating an effective learning environment because they can provide an additional opportunity for exchanging educational information and knowledge among teachers and students work in the lab, as mentioned:

> *"Collaboration is an essential ingredient in the recipe to create an effective learning environment in engineering education, as it provides students with the opportunity to discuss, argue, and exchange information or knowledge. The collaboration between students working actively in small groups can help them to work more productively in the laboratory and also learn more easily." (pp.2)*

Currently, several projects have provided an opportunity to students for collaborating and cooperating by using remote experiments, for example the NetLab and VISIR projects. NetLab project allows students to perform experiments on real equipment, which are installed at the University of South Australia (UniSA) in Australia, over the Internet [74][91][92]. Likewise, VISIR has proven to be a good system for collaboration and cooperation among researchers, teachers, and students. Since 2006, the number of researchers who have contributed to VISIR has been increasing. It has been serving several universities, courses, and thousands of students from different countries, worldwide. VISIR aims to allow universities collaborating among them by sharing labs recourses and courses materials, as stated in [93]:

> *"The aim of the VISIR project is establishing a VISIR Community of collaborating universities/organizations further developing the laboratory platform and sharing laboratory resources and course material." (pp.268)*

2.6 CONCLUSION

In recent decades, benefits of emerging ICT can to develop education systems and students' skills in several countries. This fact is more evident in developed countries whereas other countries, for instance MENA countries, still need to reshape their education systems to face a number of challenges that exist now. However, the proper mix of technologies within education systems can solve some challenges and meet the requirements of science and engineering education in the MENA countries.

Nowadays, existing technologies are being used to support learning and teaching, especially in STEM fields. Increasingly, these technologies, such as online labs, have included value to education systems and supported the development of collaborative and cooperative work among researchers, teachers, and students by working together on online experiments. Furthermore, they can help developing students' skills and their knowledge by sharing materials and resources, especially in science and engineering fields.

Summing up, online labs are a new form of increasing collaborative and cooperative work among teachers and students, in general, and in the MENA region, in particular.

"Travelling - it leaves you speechless, then turns you into a storyteller"

Ibn Battuta (1304-1368)

CHAPTER 3.

RESEARCH METHODOLOGY

Abstract

A research methodology outlines a systematic way to address a research problem by identifying the methods used, reviewing literature, collecting data, specifying and discussing results, etc. In general, it is a generic framework for attaining the objective of the research study and has become a tendency to design research in several studies. Overall, the research methodology of this thesis implies several phases that lead to the study's objectives, significance of what needs to be done, and sense how all objectives can be worked out.

3.1 INTRODUCTION

Yearly, new literature addressing methodologies that are concerned to research is released. In general, a research methodology entails a reduced number of well-defined tools and processes for reviewing and collecting data of study [94]. Nowadays, one should follow a research methodology for writing a dissertation because it can describe the broad philosophical underpinning of the chosen research methods, including whether to use qualitative and quantitative methods. In addition, the research methodology can link the literature review with certain methods that are used in a dissertation. It should explain what was done with all the choices that were made and be linked back to the literature review of study [95]; give the answers to the questions, systematically, and allow the researcher to find out the final results by using different criteria for solving the research problems [96].

This chapter describes the research methodology used in this dissertation. It is structured as follows: Section 2 provides an overview of the methodology's definition. Section 3 details the methodology's phases, namely Evaluation, Measurable Objectives, Barriers to Evaluation, Data Collection Method, Analysis and Reporting Results, and Implement the Solution, sequentially. Finally, section 4 concludes the chapter.

3.2 DEFINITION OF THE RESEARCH METHODOLOGY

Research methodology is a systematic way to solve a problem by giving the work plan of the applied research. Essentially, by giving a clear cut idea on what methods or processes can be used in the research to achieve the research objectives [97], as Rajasekar et al. defined:

> *"Research methodology is a systematic way to solve a problem. It is a science of studying how research is to be carried out. Essentially, the procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology. It is also defined as the study of methods by which knowledge is gained. Its aim is to give the work plan of research." (pp.5)*

Likewise, Kothari defined research methodology in her book, as follows [98]:

> *"Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically. In it we study the various steps that are generally adopted by a researcher in studying his research problem along with the logic behind them."(pp.8)*

A research methodology can guide the researchers and keep them on the right track for achieving the research objectives [96]. In addition, the research methodology depicts the methods and techniques that are used for collecting quantitative and qualitative data. It can explain how the research was carried out, where data came from, what sort of "*Quantitative and Qualitative"* data was obtained, which gathering techniques were used, what was the analysis of research findings, and so forth. This explanation can help researchers and readers to have enough information and details of the study research and its goals [99], and it is especially important in the context of a long investigation, as it happens in a PhD work.

Furthermore, a research methodology can support several academic disciplines such as health, education, science and engineering, psychology, and marketing to a variety of research paradigms, as Kumar stated [100]:

> *"Research methodology is taught as a supporting subject in several ways in many academic disciplines at various levels by people committed to a variety of research paradigms." (pp.36)*

In result, it is necessary for the researcher who is doing a project, dissertation, or anything similar to know the research methodology, and not only the research methods and techniques [98].

3.3 RESEARCH METHODOLOGY OF DISSERTATION

The research methodology of this dissertation comprises six phases that encompass a process for planning an objectives-based evaluation, see figure 3.1. This research methodology explains when, where, and how the research was done. In addition, it includes informative headings (e.g., evaluation criteria) for describing, analyzing, and discussing methods that are used in this study, and then finding the answers to the research questions.

The ultimate goal is to evaluate the higher education systems in the MENA region and then to give some suggestions and directions that can help improving them [33].

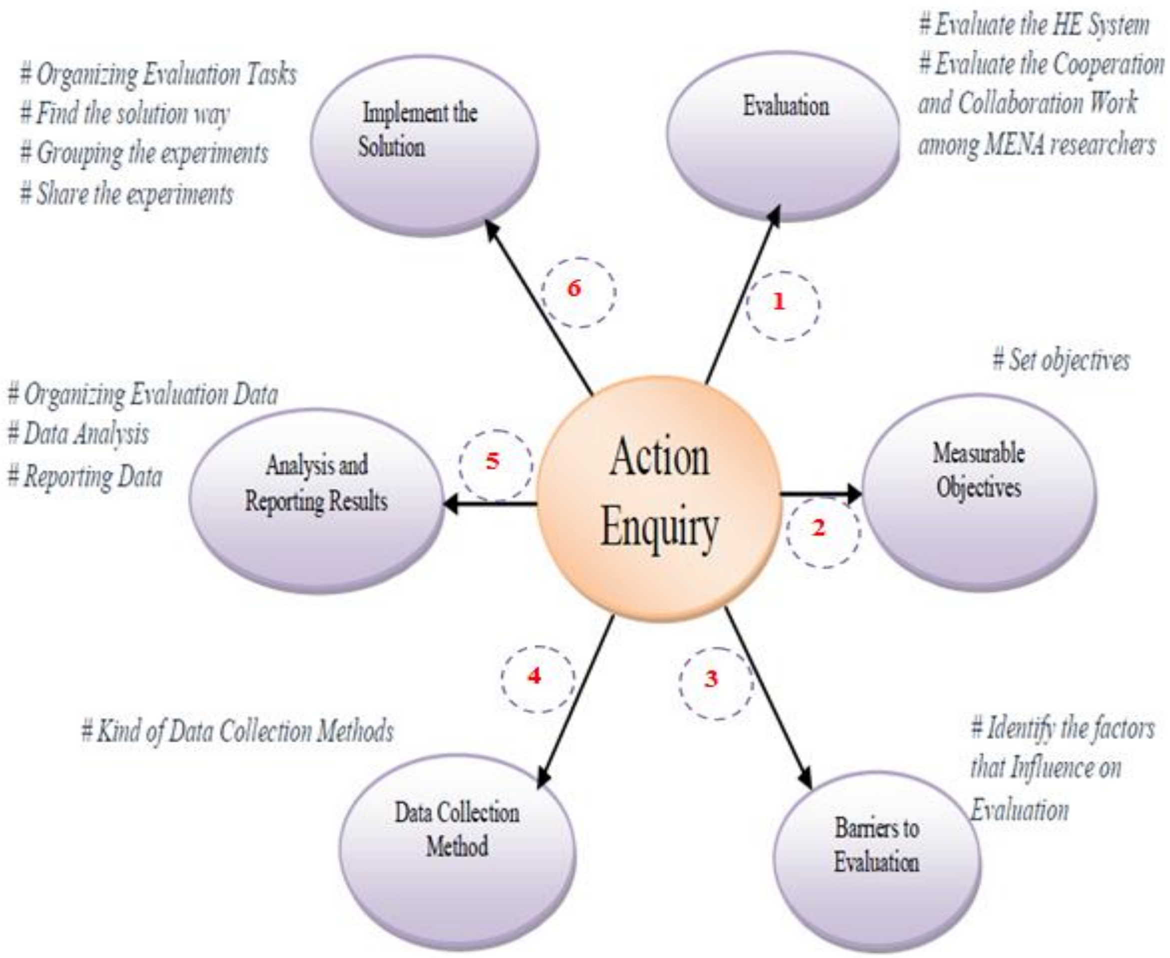


Figure 3.1: Research Methodology of Dissertation (As taken from Reference [8])

3.3.1 EVALUATION

The purpose of the evaluation is to identify the problems and determine how improvements can be made. It is important to evaluate any study because it can deal with the research questions and determine ways of improving the research by bringing a well-designed evaluation [101][102].

This phase corresponds to an evaluation of the higher education systems in the MENA region and the level of collaborative and cooperative work among researchers in the field of online labs. According to [15], the higher education systems in the MENA region are still not well improved. Therefore, the main research questions specified in this phase are [15]:

- Why is the collaboration and cooperation in the MENA region so weak?
- How can the higher education systems in the MENA region be improved?
- What kind of instructional technologies may help MENA countries enhancing their higher education systems to fit the 21st century?

3.3.2 MEASURABLE OBJECTIVES

Currently, many instructional technologies can help the higher education systems. These instructional technologies (e.g. online labs) can help students and teachers increase their knowledge and skills, scaffold students' learning, raise cooperative and collaborative work among researchers, and establish a network among universities, among other positive aspects.

This phase is used to set up the study objectives. The objective of this study is to increase the degree of collaborative and cooperative work among universities and researchers in the MENA countries, especially in the online labs area. In addition, it focuses on increasing the number of institutions, teachers, and students of higher education in the MENA region that use online labs.

3.3.3 BARRIERS TO EVALUATION

This phase identifies the factors that influence evaluation. Indeed, among the factors that can affect the evaluation and improvement of the higher education systems in the MENA region are, for example, the low use of instructional technologies and also the low level of collaborative and cooperative work among MENA universities. It could be that increasing the use of technology-enhanced education tools, for instance online labs, will cause an increase in the cooperative and collaborative work among researchers and, as a consequence, improve their higher education systems.

In general, the main barrier to evaluating the work is that the researchers in the MENA region have not published many contributions about instructional technologies, specifically in online labs field. Therefore, it was difficult to obtain evidence of their collaborative and cooperative work, in the online labs domain.

3.3.4 DATA COLLECTION METHOD

Data collection method is focused on scholarly articles and researchers from the MENA region. For collecting data, some available resources have been used in this phase, for instance conferences and journals related to online labs, in order to answer and highlight the questions derived from the evaluation part. The analysis of information is based on the number of papers published in these resources. The resources are:

- ❖ The first two resources labelled as "conferences" were two major events in the online labs field, i.e. the Remote Engineering and Virtual Instrumentation (REV) conference and the IEEE Global Engineering Education Conference (EDUCON) conference.

- ❖ The second resource was a journal named the International Journal of Online Engineering (iJOE). This journal is indexed in Scopus and, more recently, in ESCI.

- ❖ The third resource was the IEEE Xplore (Digital Library search engine) using the following keywords: remote and virtual labs and/or MENA region.

These criteria have been used in a recent paper [33], as shown in table 3-1:

Table 3-1: Data Collection Resources (As taken from Reference [8])

RESOURCES NAME	TYPE	FROM-TO
REV	Conference	2004-2014
EDUCON	Conference	2010-2014
iJOE	Journal	2006-2014
IEEE Xplore	Search Engine	Unspecified

Furthermore, in order to avoid double entries, the following criteria was used:

- ❖ Any paper presented in REV or EDUCON is not considered in the IEEE list, even if indexed there.

- ❖ Any paper found in the IEEE Digital Library and not listed in either REV or EDUCON has been included in the IEEE list.

These criteria allowed a better comparison between the REV and EDUCON conferences and enabled to find the percentage of MENA researchers present in these two conferences [103].

3.3.5 ANALYSIS AND REPORTING RESULTS

As described in the data collection method phase, resources were categorized into four entities: REV conference, EDUCON conference, iJOE journal, and IEEE digital library. In general, this phase determines the collaboration and cooperation work among MENA researchers, which is described in the data collection method phase. Afterwards, the results of the analysis were discussed according to the following criteria [103]:

- Compute the total number of researchers and papers found in these resources.
- Compare between REV and EDUCON conferences (number of papers published each year, authors' country, and which one has more influence on researchers and why).
- Determine the number of collaborative and cooperative work among the researchers.

3.3.6 IMPLEMENT THE SOLUTION

This phase is used to find solutions and some ways to assist the higher education systems in the MENA region, for instance using instructional technologies. The result of using instructional technologies, such as online labs, can help to build a network among teachers and researchers, especially in science and engineering fields. In addition, it can help to convince and involve the MENA universities to be a part of an online labs federation, which is meant to help them "*collaborating with other universities worldwide in the online labs domain*".

In general, by using the instructional technology *Online Labs* the aim is to help the teachers, students, and researchers to share experiments and resources among their universities. This also helps to strengthen relations between the MENA authors. Finally, it improves the practical skills of students, especially in science and engineering studies.

3.4 CONCLUSION

This chapter introduced and discussed the choice of a research methodology suitable for this dissertation. This research methodology is divided into six phases and guided to:

- **Evaluation phase:** used to evaluate the higher education systems in the MENA region, and show the level of collaborative and cooperative work among MENA's researchers in the online labs field.

- **Measurable Objectives phase:** used to set up the objectives.

- Barriers to Evaluation phase: used to identify the barriers that may affect the work evaluation.

- **Data Collection Method phase:** used to know what kind of data can be used in this study, where data come from, and what criteria was used for collecting data.

- **Analysis and Reporting Results phase:** used to describe, analyse, and report results on the data collected from different resources.

- **Implement the Solution Phase:** used to find the ways that can help supporting the higher education systems, researchers, teachers, and students of the MENA region in science and engineering areas.

Overall, the conclusion of this chapter is:

- Higher education systems in the MENA region need to reshape.

- Collaborative and cooperative work among MENA researchers is still not strong.

Therefore, MENA countries must increase the use of instructional technologies in their higher education systems for supporting collaborative and cooperative work among researchers. This can happen through the combination of three directions, as shown in figure 3.2.

- **First Direction:** Using Instructional Technologies, in particular online labs such as VISIR (CHAPTER 4).

- **Second Direction:** Creating a Community of Practice (CoP), in particular a Community of Practice around Online Labs (CHAPTER 5).

- **Third Direction:** Creating a Federation of Online Labs, in particular a VISIR Federation (CHAPTER 6).

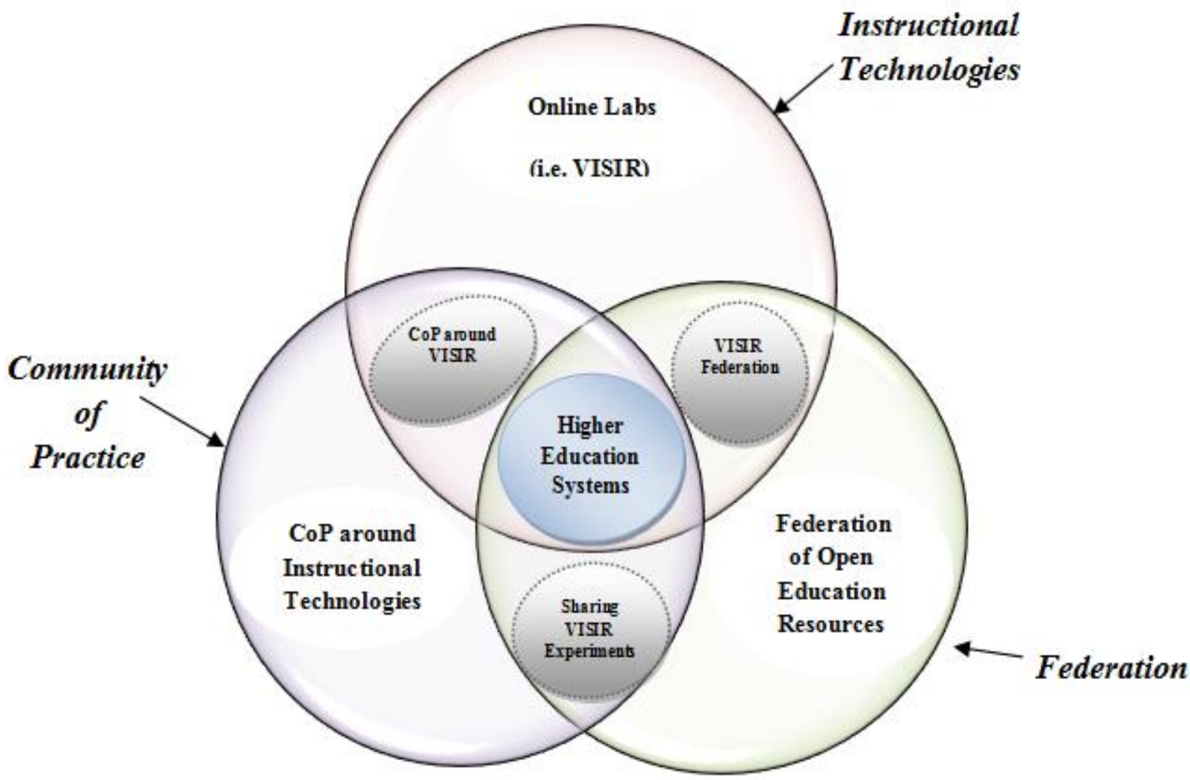


Figure 3.2: Directions for Supporting Higher Education Systems in the MENA Region

"Education is what remains after one has forgotten what one has learned in school"

Albert Einstein (1879-1955)

CHAPTER 4.

THE VISIR OPEN LAB PLATFORM

Abstract

The widespread availability of ICT has enhanced education, especially in the area of distance learning. In Science, Technology, Engineering and Math disciplines, teachers are always searching for ways to allow students to practice more time. Today, Internet technologies became more common in universities, worldwide. Online labs are especially useful for science and engineering departments that may have limited access to laboratories, particularly when expensive equipment is necessary. Online labs allow students to do remote experiments 24/7 from anywhere, at anytime, including from home or local Wi-Fi

4.1 INTRODUCTION

Vividly, it is possible to scaffold students learning skills by including technologies in education. These technologies, for instance online labs, can support curriculums without significantly raising the cost of education, by opening the labs 24/7 and allowing students to perform experiments remotely.

Online labs support students by providing them with additional opportunities to access experiments and resources. Using online labs, students are granted more time to complete laboratory activities and they can repeat an experiment as many times as necessary, with or without modification.

This chapter focuses on the concept of online labs, particularly on the Virtual Instrument Systems in Reality (VISIR) platform. This platform was developed at the Blekinge Institute of Technology (BTH), in Sweden. It provides remote access to instructional laboratories and allows students to perform physical experiments over the Internet.

The remainder of this chapter is structured as follows: Section 2 provides a brief history of the VISIR system. Section 3 presents by VISIR platform plus a description of the hardware and software parts of the VISIR system. Section 4 presents the web interfaces of the VISIR system. Section 5 shows some working scenarios of the VISIR system. Section 6 highlights some VISIR activities. Finally, the conclusion is presented in section 7.

4.2 A BRIEF HISTORY OF VISIR

In 1999, BTH started a remote laboratory project as a feasibility study. The project idea was to create online labs similar to a hands-on laboratory in campus for electrical experiments. The vision was to provide students with free access to experimentation resources remotely, without a substantial increase in cost. In 2006, the project was renamed VISIR. This name became famous among online labs researchers. Currently, there are ten nodes installed in ten different institutions in seven countries. These nodes are in Sweden, Spain (two nodes), Portugal, Austria (two nodes) [104], India, Georgia [105], and Brazil (two nodes), as shown in figure 4.1.

Figure 4.1: VISIR Nodes Worldwide

Even if the main objective of VISIR is to allow students to perform electrical and electronics experiments remotely, VISIR also supports other types of activities. For instance, it allows collaborative work among researchers, via the sharing of experiments that those researchers have designed. In 2015, VISIR was awarded the best remote controlled laboratory by the Global Online Laboratory Consortium (GOLC)[i]. Moreover,

[i] http://www.medisonuniversity.org/news.html

VISIR motivated several researchers under a so-called a Special Interest Group (SIG)[i] and almost all of its research papers have been included in a MENDELEY platform, named VISIR Activities. Today, VISIR is routinely present in several international events, for instance the International Conference on Remote Engineering and Virtual Instrumentation (REV)[ii] conference editions, the IEEE Global Engineering Education Conference (EDUCON)[iii] conference editions, the Technology, Learning and Teaching of Electronics Conference (TAEE)[iv], the American Society for Engineering Education (ASEE)[v] group conferences, the Experiment@ International Conference (exp.at) series[vi], etc.

4.3 ARCHITECTURE

Generally, the VISIR system comprehends two main sections: the Hardware section and the Software section [105]. The Hardware section includes three parts: PC-Based Platform, PXI-Based Platform[vii], and Relay Switching Matrix. The Software section includes four parts: Web Interfaces, Experiments Client, Measurements Server, and Equipment Server.

4.3.1 HARDWARE SECTION

The PC-Based Platform, the PXI-Based Platform, and the Relay Switching Matrix are connected through cables such as PCI express serial port, USB cables, and specific cables connectors. Figure 4.2 shows the VISIR system Hardware parts in detail.

---

[i] http://www.online-engineering.org/SIG_visir.php

[ii] http://www.rev-conference.org/

[iii] http://educon-conference.org/

[iv] http://www.taee2016.org/index.php/en/

[v] https://www.asee.org/

[vi] http://expat.org.pt/home/

[vii] There is an LXI-based alternative that was developed by Unai Hernández-Jayo, as part of his PhD work. Both the University of Deusto and an Institution of Higher Education in Georgia have these versions installed.

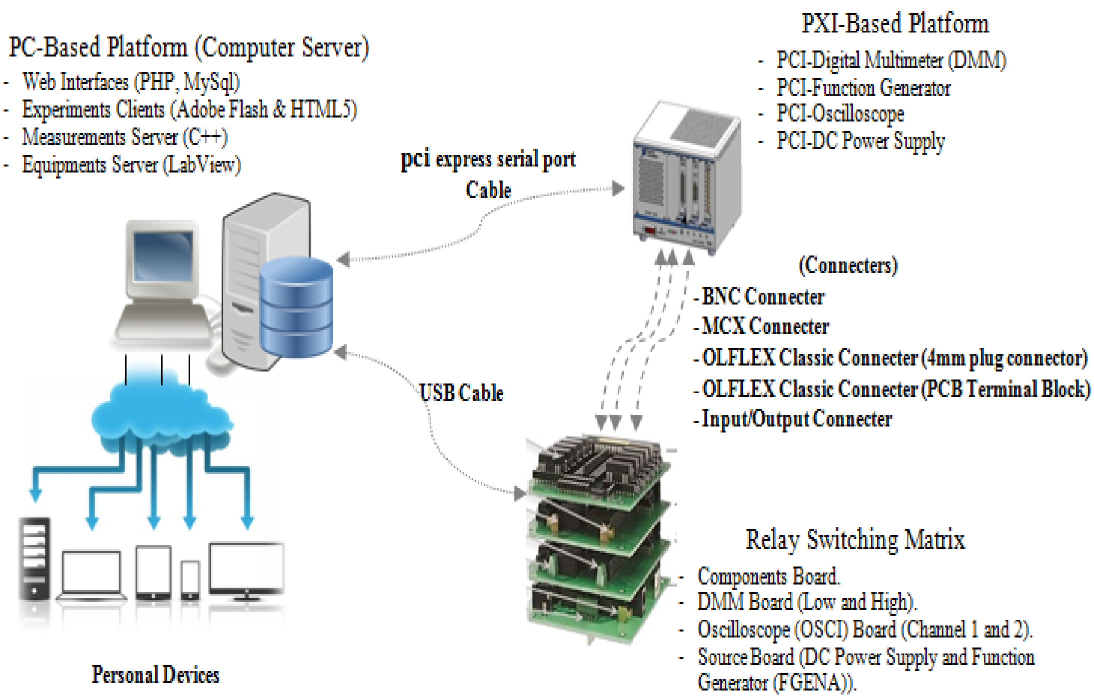


Figure 4.2: VISIR System Platform (Hardware Section)

- **PC-Based Platform**: It is a computer server that hosts a set of software programs for providing functionality to the PXI-Based Platform and the Relay Switching Matrix parts. It is designed as a Client–Server model and provides various functionalities for sharing data and resources among users. The PC-Based Platform is connected with the PXI-Based Platform and the Relay Switching Matrix over a PCI Express Serial port and USB cables, respectively.

- **PXI-Based Platform**: This platform hosts the instruments module cards. The backbone of the PXI-Based platform is the NI PXI-Chassis (NI PXI-1033), where instruments modules cards are plugged into. Instruments modules cards can be added and removed depending on demands. These modules cards are the NI PXI-DC Power Supply (PXI-4110), the NI PXI-Digital Multi-meter “DMM” (PXI-4072), the NI PXI-Function Generator (PXI-5412), and the NI PXI-Oscilloscope (PXI-5114). All of them are manufactured by National Instruments (NI)[i]. This platform is connected with the PC-Based Platform through a PCIe card (NI-PCIe 8361) and over a PCI Express Serial Port Cable.

- **Relay Switching Matrix:** It is a stack of boards acting as a circuit wiring robot. It is manufactured by a company named Open Labs, in Sweden. It is designed for electronic circuit experiments. Normally, it consists of different board types: Components Board, DMM Board (Low and High), Oscilloscope Board (Channel 1 and 2), and Source Board (DC Power Supply and Function Generator (FGENA)), as shown in figure 4.3. Currently, there is a new version of components board manufactured and included in the Relay Switching Matrix. This board has all possible connection combinations of two components (see figure 4.4). In general, the Relay Switching Matrix is connected with the PC-Based Platform over an USB cable and also with the PXI-Based Platform over several probes.

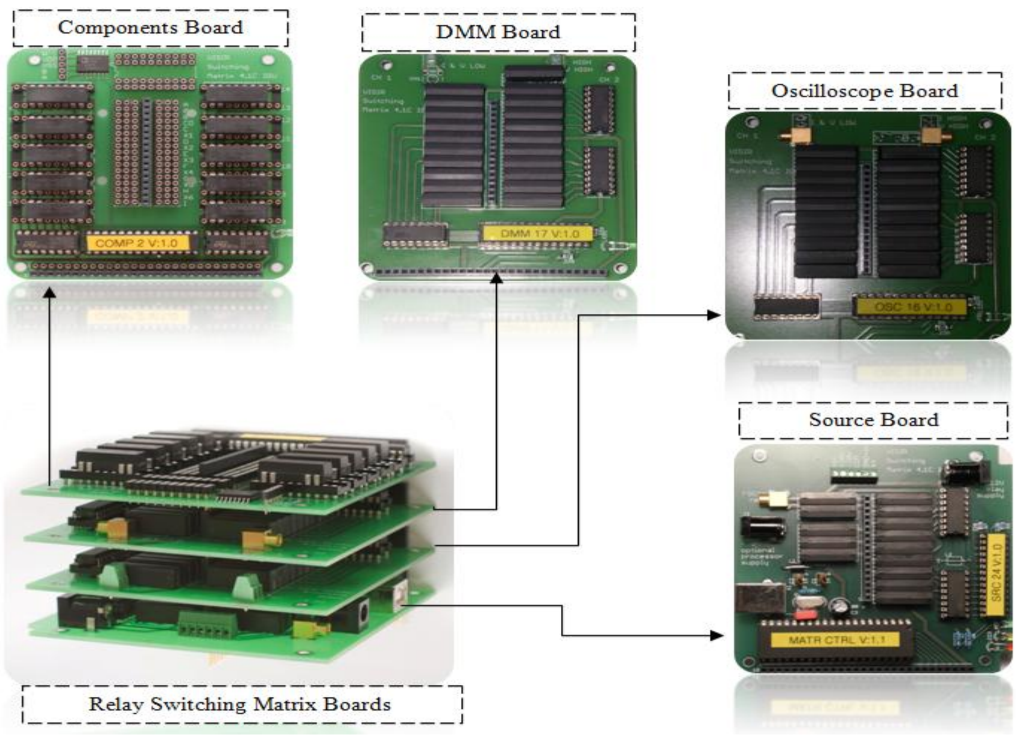


Figure 4.3: Relay Switching Matrix Boards

[i] http://www.ni.com/en-gb/support.html

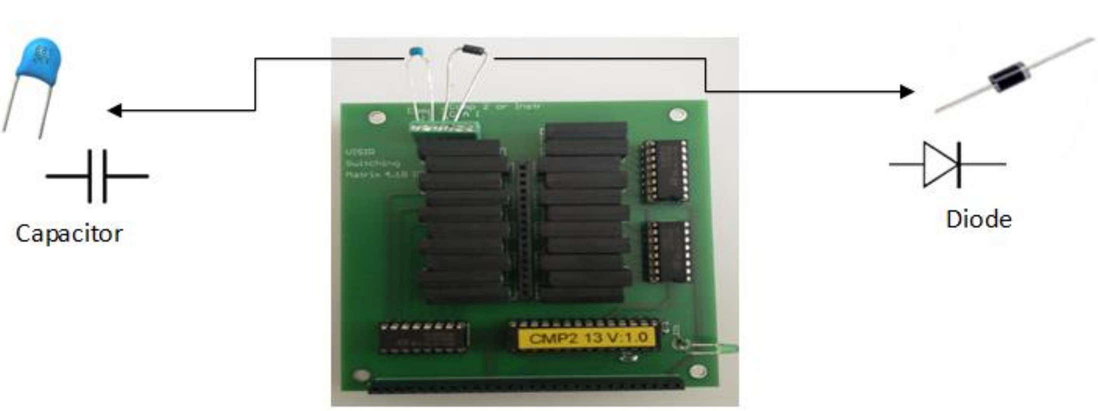


Figure 4.4: A New Version of Components Board (Dual Components Board)

The cables used to connect the PXI-Based Platform and the Relay Switching Matrix are BNC, Micro Coaxial (MCX), OLFLEX Classic (4mm plug connector), OLFLEX Classic (PCB Terminal Block), and DC-Output connectors, as shown in figure 5. BNC connector and MCX connector are used to connect PXI-Oscilloscope and Oscilloscope Board, and PXI-Function Generator with Source Board. Output connector and Terminal Block connector are used to connect PXI-DC Power Supply Board and Source Board. Plug connector and Terminal Block connector are used to connect PXI-Digital Multimeter (DMM) and DMM Board.

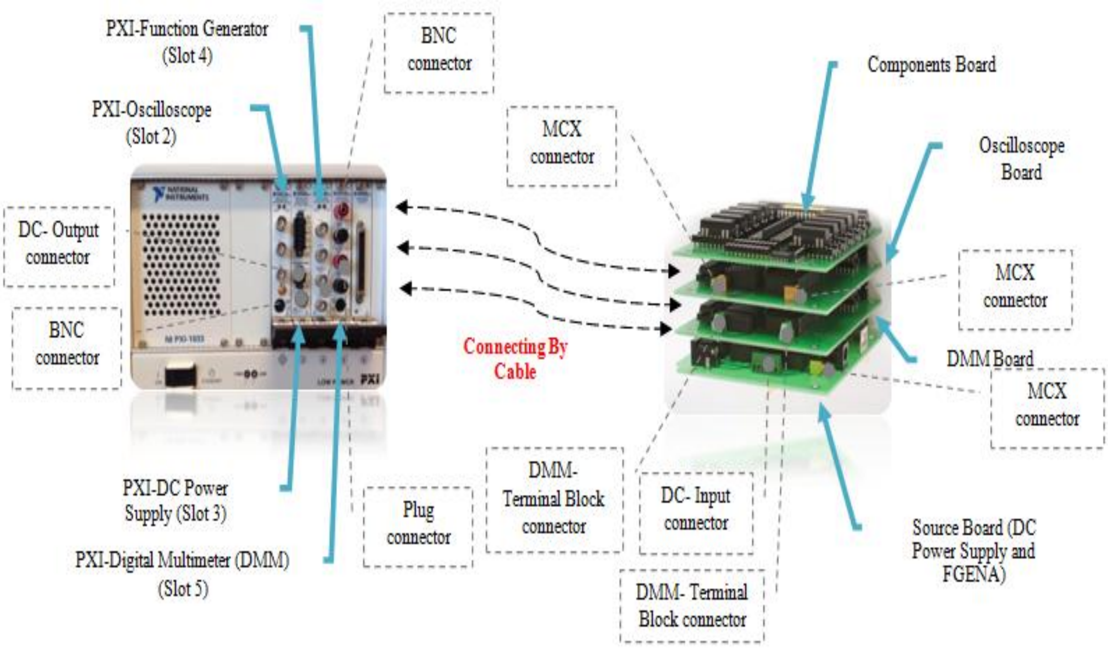


Figure 4.5: Cable Connectors between the PXI-Based Platform and the Relay Switching Matrix

4.3.2 SOFTWARE SECTION

All software parts (web interfaces, experiments clients, measurements server, and equipment server) have been hosted in the PC-Based Platform [106][107]. The software code of the VISIR system is grouped in one folder, which is called trunk[i].

- **Web Interfaces:** the source code of the VISIR interfaces was written in PHP language and MySQL. It is installed in the PC-Based platform and assigned for VISIR. The code of VISIR is open source code. This characteristic helps to integrate VISIR with other environments, such as Learning Management Systems (LMSs) and social networks. In addition, it has been integrated with other platform projects, such as Go-LAB and WebLab-Deusto. Currently, the text resources used in the code of the VISIR web interfaces are available in several languages: English, Swedish, Greek, Spanish, Portuguese, Arabic, and Kurdish[ii].

- **Experiments Client:** This part was initially written in Adobe Flash to display the virtual interface of the breadboard and each instruments board (Function Generator, DC Power Supply, Digital Multi-Meter, and Oscilloscope). More recently, this part has been re-written in HTML5.

- **Measurements Server:** This part was written in Microsoft Visual C++. It receives the measurements requests that come from experiments clients. Each request is sent through a separate TCP session. The requests and responses should not be sized more than 64KB. Furthermore, there are four steps handled by the measurements server: (i) Authentication, (ii) Validation, (iii) Time-sharing, and (iv) Controlling. Authentication (i) is used to check whether the client is a valid user or not. If not, the client must activite his VISIR account, through a valid email address. Circuit validation (ii) is used

---

[i] http://svn.openlabs.bth.se/trac/openlabsweb/browser/trunk?rev=448&order=name

[ii] The Kurdish and Arabic interface was produced within the context of the present PhD work. http://svn.openlabs.bth.se/trac/openlabsweb/browser/trunk/common/lang

to compare the received circuit data with the “maxlist” file, before sending a request to run the real instruments. This step is done to avoid damaging the instruments as well. Time-sharing (iii) handles requests from clients and is able to handle simultaneous requests typically within less than one second per request. Controlling (iv) is used to handle requests directly over TCP/IP to the equipment server.

- **Equipment Server:** The equipment server was written in LabVIEW. It is a stand-alone equipment controller, handling the low-level instrument interfaces. It handles the communication among the PC-Based Platform, the PXI-Based Platform, and the Relay Switching Matrix parts, through LabVIEW.

4.4 WEB INTERFACES

The VISIR web interfaces include stationary and dynamic pages. Stationary pages are Wiki pages that are written in HTML language. Dynamic pages are Experiment pages that are written in Flash or HTML5. They are controlled by the application server processing server-side scripts. The entry Wiki page contains Language, Login, Main Menu, and welcome message. Users can select any of the currently supported languages: English (EN), Swedish (SV), Spanish (SP), Portuguese (PT), and Greek (EL). The set of languages available in each VISIR site varies. For instance, the VISIR node at IPP-ISEPi, in Portugal, supports five languages, while VISIR at BTH[ii], in Sweden, has just two languages [108], right now. The new VISIR node at IPP-ISEP, which was installed during the course of this PhD work, supports additional languages[iii]: Arabic (AR), Kurdish (KU), Polish (PL), and Dutch (NL), see figure 4.6.

---

[i] https://physicslabfarm.isep.ipp.pt/

[ii] http://openlabs.bth.se/electronics/index.php/en

[iii] VISIR web interfaces have been translated to Arabic, Kurdish, Polish, and Dutch Languages. Arabic and Kurdish languages are available in the VISIR source code online, as mentioned before. Polish and Dutch are not included in the VISIR source code online presently; they are just included in the new VISIR node at IPP-ISEP.

The login button allows a user to access the VISIR system. Users may be guests or have authorization to access the system. If the users have credentials to access VISIR they can login by using username and password. The username is the email used during activation of the account. The password can be generated automatically. Activating account is needed in the first visit only.

The main menu includes hyperlinks to “Start”, “About”, “Demo”, and “FAQ” pages. “Start” is a welcome user page that gives a short paragraph about what is an electronics laboratory. “About” is a page of history, description, manuals and references that is related to the VISIR system. “Demo” is a page that includes demonstration and guest access to the VISIR system. Frequently asked questions about VISIR are included in the “FAQ” page. The entry page interface of VISIR system at IPP-ISEP is illustrated in figure 4.6.

Figure 4.6: Front Page (Main page) of the VISIR System at IPP-ISEP

4.5 DESCRIBE VISIR: SCENARIOS

This section describes two scenarios where students and teachers interact with VISIR via the Internet. The first scenario describes how the actors (instructor, technician, admin, and teacher) collaborate to set up and prepare a new experiment, from scratch, and then how students run it. The second scenario describes how the admin and teachers collaborate to prepare a new experiment, when the experiment is already ratified by the instructor and the components are already installed by a technician, as shown in figure 4.7. Note that, the teacher can be an instructor as well, which means he can ratify the experiments before adding them to VISIR.

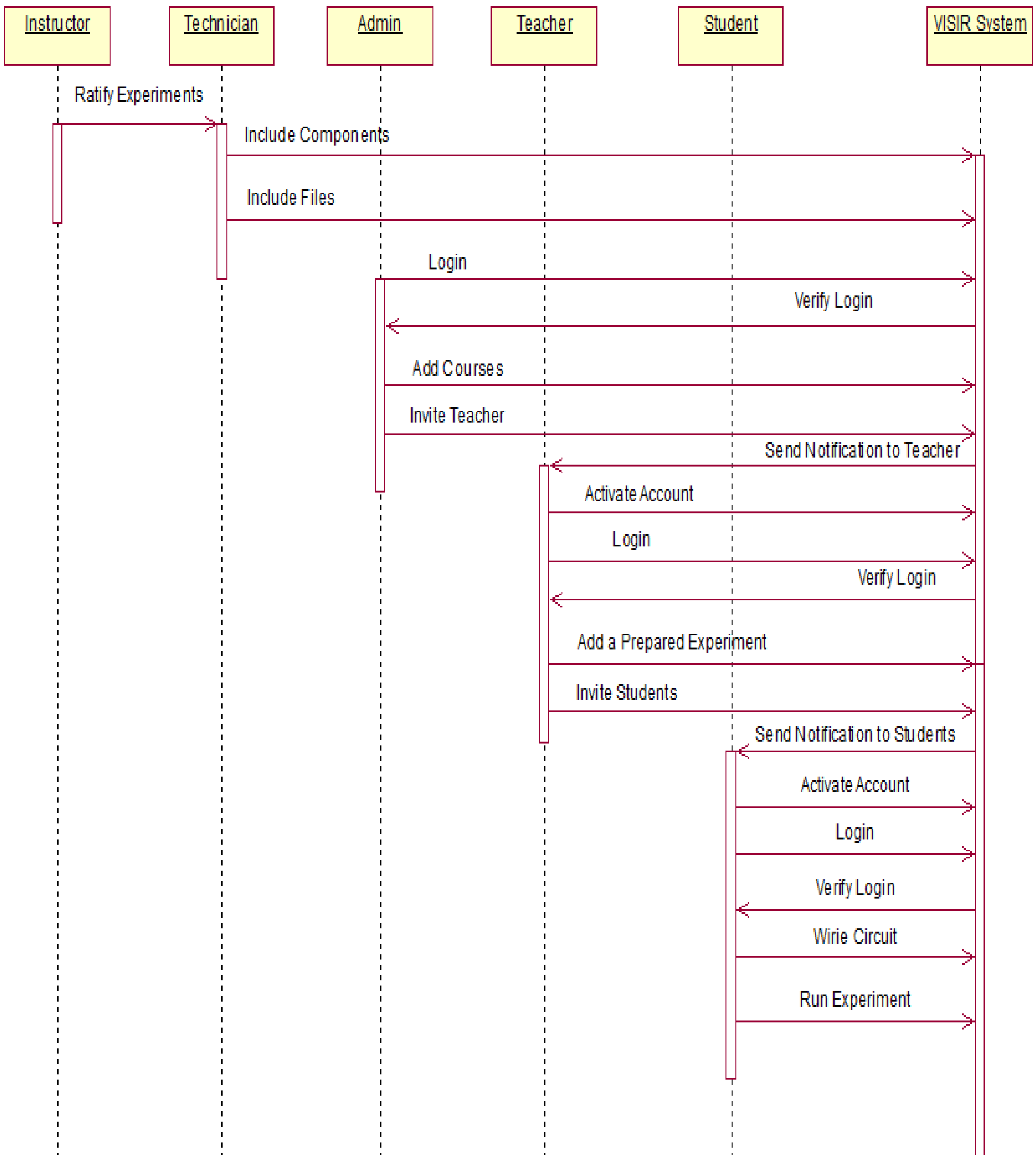


Figure 4.7: VISIR Sequence Scenarios

This scenario shows the sequence to create a new experiment for students from scratch. It must be remarked that before including a new experiment into the VISIR system the experiments must be ratified by the instructor. In fact, some experiments need to be modified for adapting them to the VISIR system. After ratification, the technician has to add the components into the VISIR system to allow users to access VISIR through the user interfaces. The technician must include or modify specific files (Component.list, Max.List, and Library.XML), which are located in the VISIR server, and include or swap the components in the Relay Switching Matrix.

Afterwards, the admin logins to VISIR through the web interfaces to add the courses by selecting the course name, start and end course date, maximum number of students, and maximum number of course seats, as shown in figure 4.8. From the same interface, teachers and students who are invited by the admin through Email can login in the VISIR system. Teachers must add a prepared experiment and can also invite students to access the experiments by using their email account.

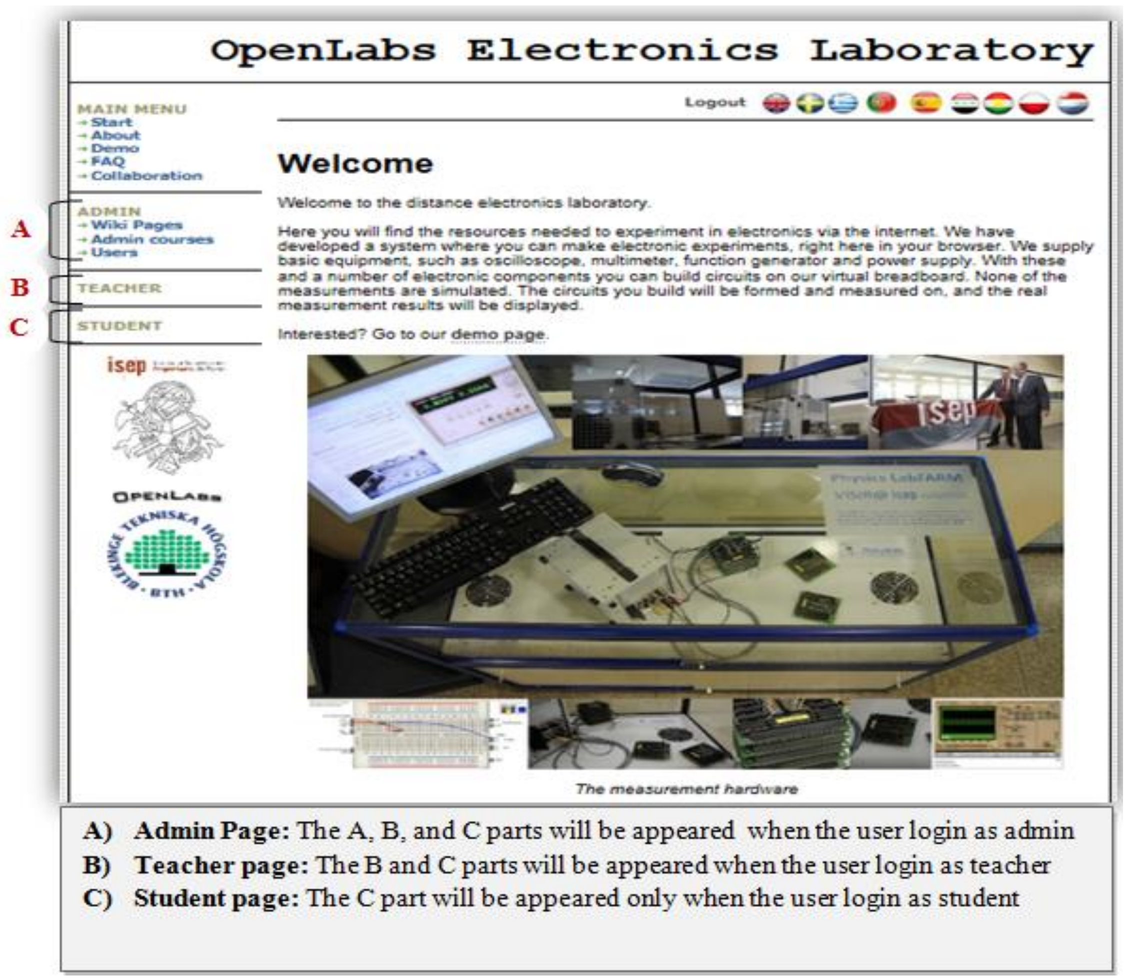


Figure 4.8: Front Page of VISIR System after Login (Admin Login Page)

Using their login and password, students can run their experiments, which are prepared by their teacher course. The students access to the experiments wire the components in the virtual board, and then run the experiments, as shown in figure 4.9. Additionally, they can complete their experiments in other days by saving and loading them.

The second scenario shows the sequence to create new courses for students from the beginning. If the experiments have already been ratified by the instructor, and components and files have already been included into the VISIR server by the technician, it just needs to involve the admin, teacher, and students.

These two scenarios have been described in the VISIR teacher and student manuals in detail [109][110][111].

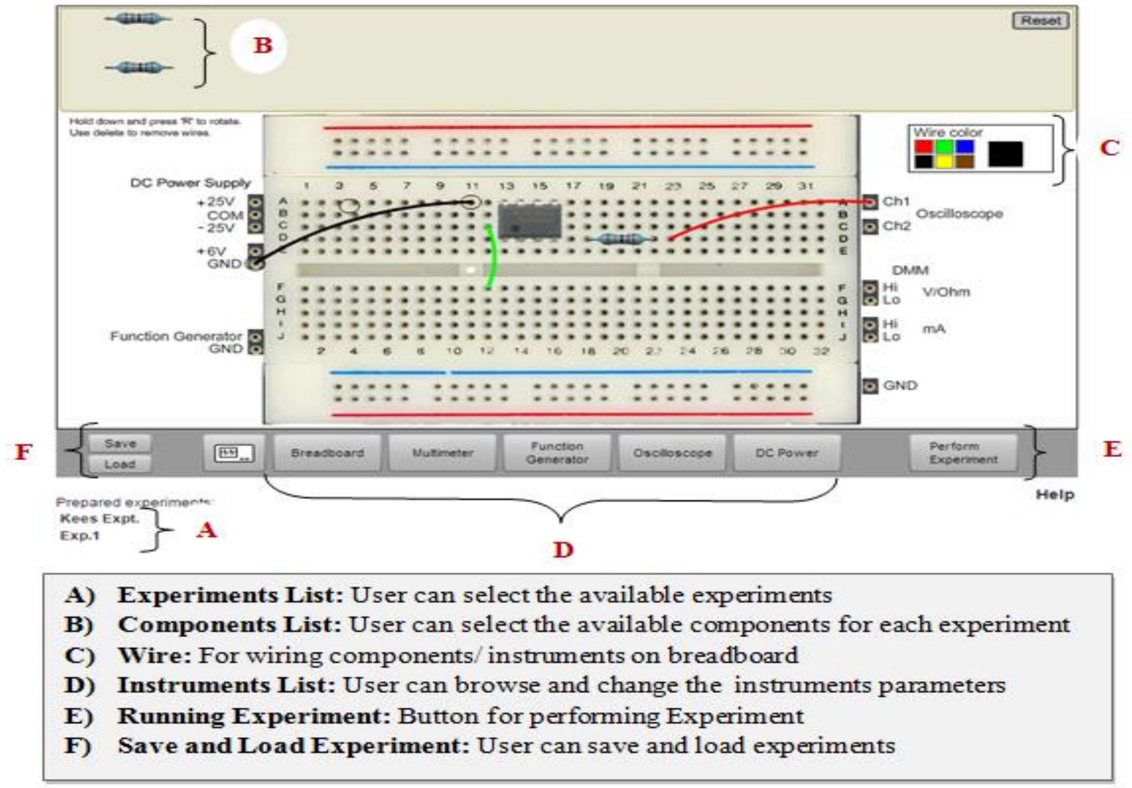


Figure 4.9 Experiment Page for Running Experiments in the VISIR System (Students Login)

4.6 VISIR ACTIVITIES

Day by day, the VISIR system is proving itself to be a good solution in the teaching and learning of electric and electronic circuits theory and practice [112][113]. Several activities are being done with the support of VISIR, for instance (i) serving students from different countries, (ii) increasing collaborative work among researchers, including different subjects and courses, (iii) integration with other educational environments, and (iv) looking for lower cost alternatives.

4.6.1 STUDENTS AND COURSES

From 2006 until now, thousands of students have benefited from VISIR. They were from different cultures, languages, and educational environments. These students have used different VISIR nodes worldwide. VISIR is involved in several courses and programmes of study from different fields [105][112][114]. For example, Circuit Analysis at Blekinge Institute of Technology (Sweden), Electronic Circuits and Components at University of Deusto (Spain), Applied Instrumentation at Polytechnic of Porto (Portugal), Foundations on Electronic Engineering at National University of Distance Education (Spain), Operational Amplifiers at Federal Institute of Santa Catarina (Brazil), and Instrumentations and Control Systems at Al-Quds University (West Bank- Palestine) [105].

Furthermore, VISIR has not only served higher education students, but also secondary school students as well, for instance Katedralskolan Secondary School (Sweden) and Urdaneta School (Spain), in subjects like Physics, with AC/DC Experiments (Ohm's & Kirchhoff's laws) [105].

4.6.2 COLLABORATIVE WORKS

VISIR gathers researchers from different countries, in the same area of the world or even in different continents. These researchers have been working together for sharing resources, experiments, pedagogical approaches, and so on. For example, European researchers have been working with South American or North American researchers, or with Asian researchers. According to Ingvar [i] Gustavsson's message dated 31,

[i] Ingvar Gustavsson is the creator of the VISIR system. He works at BTH (Sweden).

December 2013, VISIR researchers have always contributed to events like REV, EDUCON, and TAEE through publications, communities, or workshops[i].

In October 2015, a group of VISIR researchers and scientists, from Portugal, Spain, Austria, Brazil, Argentina and Sweden, started the VISIR+ project[ii]. In addition, they made several workshops on how can the VISIR system be further enhanced to give students more opportunities for performing physics and electronics experiments via the Internet [115].

Currently, there is an open community group for VISIR researchers. It is called VISIR SIG, and it is managed by the International Association of Online Engineering (IAOE) and GOLC[iii]. This group is organized for people who are interested in online labs, especially in opening university laboratories for remote access 24/7.

The resources of the VISIR system can be found in a private Dropbox folder and in the MENDELEY platform. The IAOE VISIR SIG page, the VISIR Dropbox[iv], and the VISIR MENDELEY group are just different collaborative and dissemination spaces used and managed by members of the VISIR SIG.

In total, it can be noticed that the number of researchers involved in VISIR activities has increased to more than one hundred. Therefore, all these activities may help to increase the number of VISIR researchers, even more, in the days ahead [105][116].

4.6.3 INTEGRATION WITH OTHER ENVIRONMENTS

As mentioned before, the VISIR platform is based on open source code. This feature allowed several researchers to integrate VISIR with other platforms [117] such as LMS, Open Labs projects, and Social Networks, among others. For example, IPP-ISEP and the University of Deusto have integrated VISIR with Moodle [118], while the Spanish

---

[i] http://lists.online-lists.org/pipermail/sig-visir/2013-December/000001.html

[ii] http://www2.isep.ipp.pt/visir/

[iii] http://online-engineering.org/SIG_visir.php

[iv] https://www.dropbox.com/sh/brak7jib2ro3qva/AAA-Iig-Yv037kOfPUw-PxK2a?dl=0

University for Distance Education (UNED) has integrated VISIR within its own Massive Open Online Course (MOOC) platform. Another example, VISIR has been integrated into other online labs projects, for example Go-LAB project [[119], page 124] and WebLab-Deusto project [106][120].

Furthermore, VISIR is integrated with remote labs brokerage platforms for instance iLab Shared Architecture (ISA) [73][105][121] at Massachusetts Institute of Technology (MIT). In addition, it is also integrated into Social Networks, for example WebLab-Deusto users can run the VISIR experiments through Facebook [120].

4.6.4 LOWER-COST PLATFORM

The VISIR system originally developed at BTH comprehended an instruments platform based on PCI eXtensions for Instrumentation (PXI-1033) platform. Later, Unai Hernandez Jayo [122], on the course of his Ph.D work, adapted the VISIR software to also support another instruments platform, i.e. LAN eXtensions for Instrumentation (LXI) in the WebLab-Deusto project at the University of Deusto [105][107][109][123][124]. Recently, National Instruments released the VirtualBench[i] platform. This platform includes a mixed-signal oscilloscope, a function generator, a digital multimeter, a DC power supply, and several digital I/Os into a single device. This means this low-cost instrument platform may be integrated in VISIR in the short future [105], see figure 4.10.

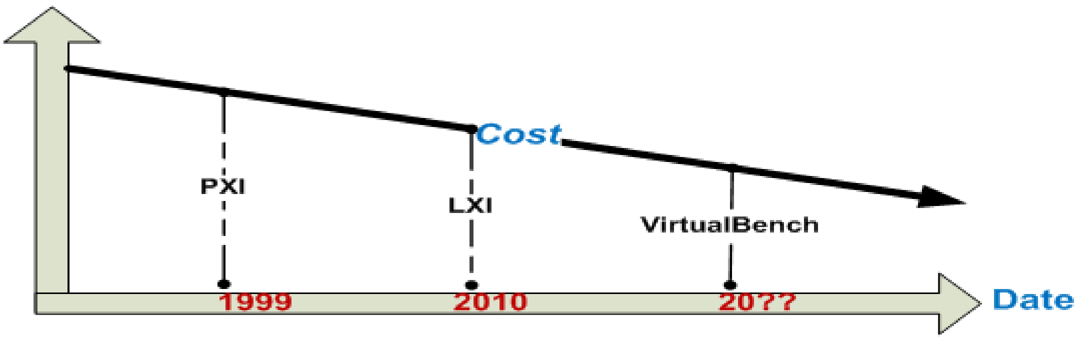


Figure 4.10: Install VISIR by Budget Cost

---

[i] http://www.ni.com/virtualbench/

Furthermore, with the support of Kees Oosterhof, an Erasmus student from the Netherlands, a second Relay Switching Matrix has been recently installed at the Polytechnic of Porto. The unpopulated Printed Circuit Boards (PCBs) and the individual components were acquired from July 2015 to March 2016 (a total of nine months), and Kees Oosterhof was able to solder all components and test all boards during his internship that lasted from February till July 2016 (five months). This Relay Switching Matrix includes the new components board (Dual Components Board) and, in total, it costs about 20% of the normal market price (person-month cost not considered).

4.7 CONCLUSION

The whole VISIR approach has taken a significant effort to implement. It has proven itself effective to serve the educational community in general, and those involved with the teaching and learning of electric and electronic circuit theory and practice in particular. Teachers and students around the world are already using VISIR through its nodes.

Since 2006, VISIR has attracted the attention of many researchers in different parts of the world. With the integration of new features as a result of activities, VISIR has become a good example of a successful online laboratory. It allows students to run their experiments 24/7. In addition, it has been adapted to be used from within other educational platforms. Currently, VISIR serves students from many countries. These students are not just from higher education; they are from secondary schools too. Moreover, the VISIR web interfaces offer various languages and the users are able to switch the language easily, via the VISIR interfaces.

As summarized in figure 4.11, three most recent results related to the VISIR activities are:

- **First:** In February 2015, VISIR was awarded the best remote controlled laboratory by GOLC.

- **Second*:*** In October 2015, VISIR has been financed by the European Union Erasmus+ Programme for expanding its platform to Brazil (Federal Institute of Santa Catarina Federal University of Santa Catarina, and the Catholic University of Rio de Janeiro) and

Argentina (National University of Santiago del Estero and National University of Rosario) [125][126]. The expansion project is led by the Polytechnic of Porto for two years and has a total funding of 668,058 €[i].

- **Third:** In October 2016, VISIR has been financed by the Erasmus+ Spanish National Agency for creating the first European federation of VISIR nodes. The project is led by UNED, for 3 years and has a total funding of approx. 250 k€[ii].

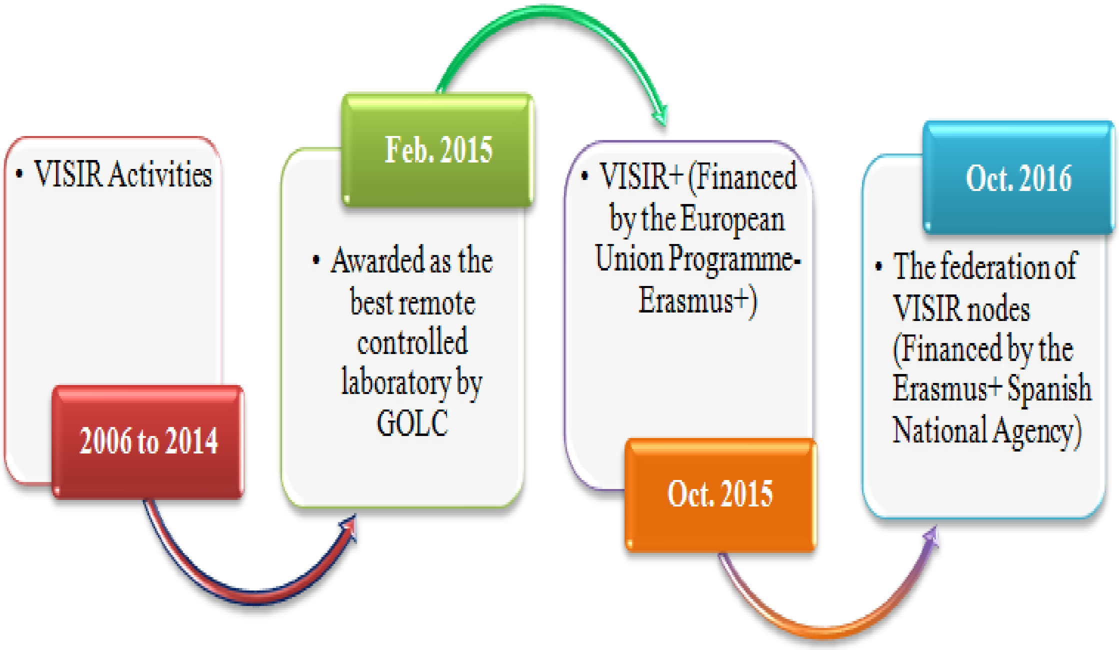


Figure 4.11: VISIR Movements from 2006 to 2016 and the Outcome of Activities

---

[i] https://eacea.ec.europa.eu/sites/eacea-site/files/eplus-cbhe-selection-results-by-region.pdf

[ii] https://tinyurl.com/kqv828g

"Coming together is a beginning; keeping together is progress; working together is success"

Henry Ford (1863-1947)

CHAPTER 5.

COMMUNITY OF PRACTICE AROUND ONLINE LABS

Abstract

A community of practice is a group of people informally bound together by a shared expertise, or by a common interest in a topic or in a set of problems. Typically, its members work for corporations, for non-profit organisations, for the government, for educational institutions. In general, a community of practice focuses on sharing best practices and creating new knowledge to advance a domain of professional practice. Hands-on experiences with innovative instructional technologies (e.g. online labs) can build confidence and skills of academic staff and students for the future, especially in science and engineering disciplines. Furthermore, those technologies have been supporting the higher education systems and developing the quality of curricula at universities. A community of practice around online labs is therefore essential for a successful integration of this instructional technology in traditional universities

5.1 INTRODUCTION

Indeed, the expression "education system" refers to a network of schools and universities. The education system provides power to the human society to develop the civilization and culture. Simply put, an education system comprises everything that goes into educating students at the national and community levels, such as public funding, resource allocations, facilities, staff, books, computers, teaching resources, and other learning materials. On the other hand, an education system is, by nature, complex and multifaceted, and the challenges entailed in reforming or improving are subject to many constraints.

Reforming any given education system, which may in principle be simple or easy, usually requires complicated state-policy changes, union-contract negotiations, or countless additional conditions [127].

Several countries in Europe and Latin America have started reforming and modernizing their higher education systems in order to promote the knowledge-based society, according to European strategy, for example Portugal [128][129].

The same approaches to improve the higher education system in United States in the twenty first century were reported by Callan et al. (2007). One of these approaches was focused on teacher quality [130]. They wrote:

> *"A third approach to improving preparation for college involves enhancing teacher quality, particularly as it relates to college readiness." (pp. 6).*

Another world region, namely the MENA region, which is geographically situated at the junction point of three continents: Asia, Europe, and Africa [131][15], has a number of general challenges in their higher education sectors. Many attempts were made to improve the higher education systems in the MENA region, for example Gulf countries try to mobilize their considerable wealth to effect change in their higher education. However, those attempts have not been able to overcome the challenges for advancing the higher education sector in this region [15][132].

Baporikar (2014) highlighted the higher education systems in the MENA region in his book [133]. He discussed the learning methods in this region and said:

> *"The education system in the MENA region does not encourage the development of cognitive and problem solving skills. Learners study through memorization and replicated production of material. The applied teaching and learning strategies cause learners to become receiving objective of information and not engage with the learning process. Long term effects of such practices in the education system can curb independent thinking and action and hence inhibit creativity of such failure relate to the inability of current education system to generate new knowledge; or transfer key skills to investment" (Chapter Two: pp. 26).*

Nowadays, several ways and technologies, which are disseminated, can help reforming education systems in the MENA region, for instance online labs technology [15][134]. In particular, it is possible to share resources, materials, and experiments among the MENA universities by creating a community of practice around online labs. These ideas may increase the collaboration and cooperation work among researchers, especially in STEM disciplines [103].

For instance, Restivo and Alves (2013) state that online labs can increase informal learning activity and facilitate student’s skills acquisition in STEM disciplines. They explained in their learning scenarios that students can acquire knowledge and skills, by using online labs, especially in Science, Technology and Engineering [135]. Furthermore, they match the learning outcomes of instructional laboratories, proposed by Feisel and Rosa [136] to online labs.

This chapter shows the method that was used to create a community of practice around online labs in the MENA region, starting by the Kurdistan Region-Iraq.

The remainder of this chapter is structured as follows: Section 2 provides a wider definition of CoP. Section 3 presents the idea, the methodology and the work plan for creating a community of practice around online labs in the MENA region. Section 4 shows the achievements supported by a community of practice around online labs. Section 5 concludes the chapter.

5.2 DEFINING COMMUNITY OF PRACTICE

Today, a group that shares in a domain of knowledge and expertise is often called a "community". In other words, for the purpose of our analysis, a community is a group of people that interacts and discuss a certain topic [137][138][139]. A specialization of "community" is "Community of Practice", which Wenger (2015) defines as follows[139]:

> *"Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.".*

A community of practice has become a popular concept in the world in recent years [140][141]. The concept of a community of practice is focused on developing the skills by interacting around problems, solutions, and insights, and building a common store of knowledge [142][143]. In addition, this concept has a number of practical applications in business, organizational design, education, and civic life. As Wenger stated [142][144]:

> *"A community of practice itself can be viewed as a simple social system."(p. 176).*

> *"In our communities of practice, we come together not only to engage in pursuing some enterprise but also to figure out how our engagement fits in the broader scheme of things" (p. 162).*

A community of practice establishes a relationship between the group and the world. For example, in education, a community of practice brings the experience of schooling in three dimensions: internally, externally, and over the students' lifetime. In general, internal focus on "*how to ground school learning experiences in practice through participation in communities around subject matters?*". External focus on "*how to connect the experience of students to actual practice through peripheral forms of participation in broader communities inside and beyond the school walls?".* Over the student's lifetime focus on *"how to serve the lifelong learning needs of students by organizing communities of practice focused on topics of continuing interest to students beyond the schooling period?*[145].

Dube et al. (2003) and Bourhis et al. (2005) identified a topology of 21 structuring characteristics on which communities of practice may differ and be compared. One of them is geographic dispersion, which is referred to the physical location of the participants [146][147].

ICT are considered the major factor to the success of CoP. They make it possible to create online communities that are characterized by strong social relationships between participants who are base in different places, anywhere in the world, and to foster strong commitment to the community goals [148]. In addition, mailing list server, newsgroup, bulletin board, Internet Relay Chat (IRC), Multi-User Dungeon (MUD), Facebook, or Blogs technologies can support to create a community [149][150]. It seems that in few years the technologies rise can be the icon of a community of practice [150].

Therefore, it is interesting to build CoPs in education systems, starting with technology-based platforms, for instance online labs, and then deciding what kinds of activities are most important for that community. Additionally, they can be a good place to start exploring a social discipline of learning [142][148].

5.3 BUILDING A COMMUNITY OF PRACTICE

Online lab technology concerns lab experiments that can be performed via the Internet. These online experiments can include a variety of subjects and disciplines from Physics, Chemistry, Biology, Technology, Engineering, Math, etc. Most online lab projects are free (meaning, can be done without paying a fee), for example VISIR, or are low-priced. The main aspect of online labs is to assist pedagogy and education by supporting teachers and students learning activities in a real and virtual environment, especially in higher education [105][116].

In general, online labs have been serving thousands of students over the world. In fact, online labs can provide great services to institutions for supporting teachers and students by sharing costly equipments and resources, which are otherwise unavailable to the large number of users in various disciplines.

In our view, the various forms of technologies that are available today can help to build a community of practice around online labs. The next subsections show the techniques used to create a community of practice around online labs in the MENA region.

5.3.1 METHODOLOGY AND WORK PLAN

Today, one must overturn the education method from delivering instruction, which is considered too simple and ineffective, in order to set the conditions for a better education, namely through active learning. This method, active learning, is considered one of the most powerful movements in education. It allows students to construct their knowledge and understanding by interacting with real problems. Furthermore, active learning can support and build upon the lecture, help the students to work together, require students to take different perspectives or come up with alternative approaches. Moreover, technologies may enhance the activity and add value to education, rather than complicating it [151].

In general, there are many different active learning methods, for instance collaborative learning and cooperative learning. Cooperative learning is used to acquire foundational knowledge for students, while collaborative learning is more open-ended, and is therefore more appropriate for higher level courses [151].

To create a community of practice around online labs we followed two different directions [152]. The first direction was to build a network with Continental and Intercontinental Communities (CICs), who work in online labs fields. The second direction was to build a network with Regional and National Communities (RNCs), who are interested in using online labs in education, as depicted in figure 5.1.

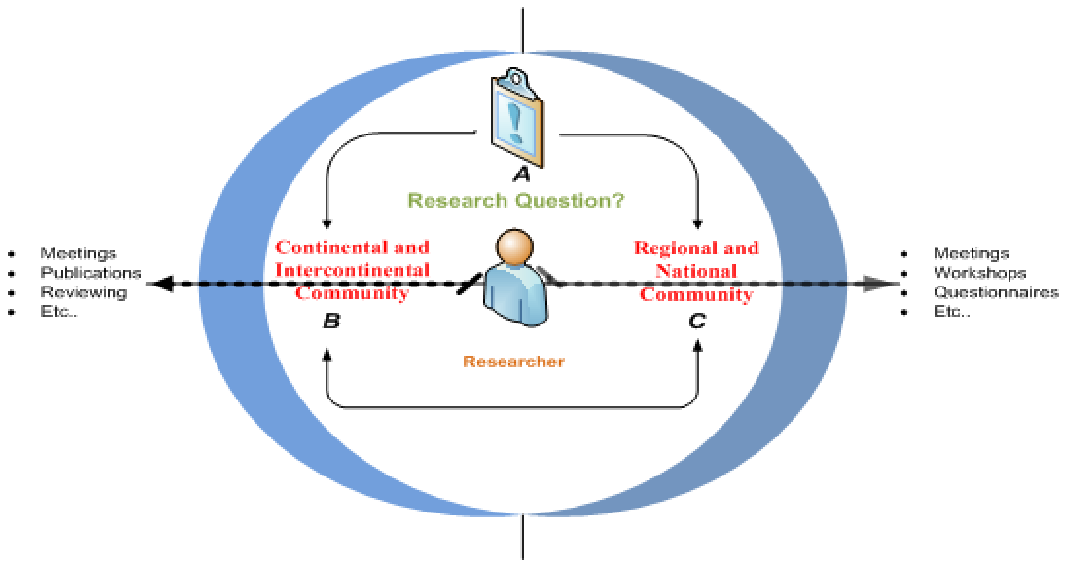


Figure 5.1: Strategy to Create a Community of Practice around Online Labs

For creating a community of practice we have picked out one research question. As shown in figure 2.5, the small numbers of doted lines (which show a working relation between two or more research groups) evidence the lack of an active cooperation in the MENA region, around the topic of online labs [15][33][103]:

> *"Why is the cooperation and collaboration among researchers, specific in the MENA region, so weak, especially in the sector of engineering and sciences fields in higher education?".*

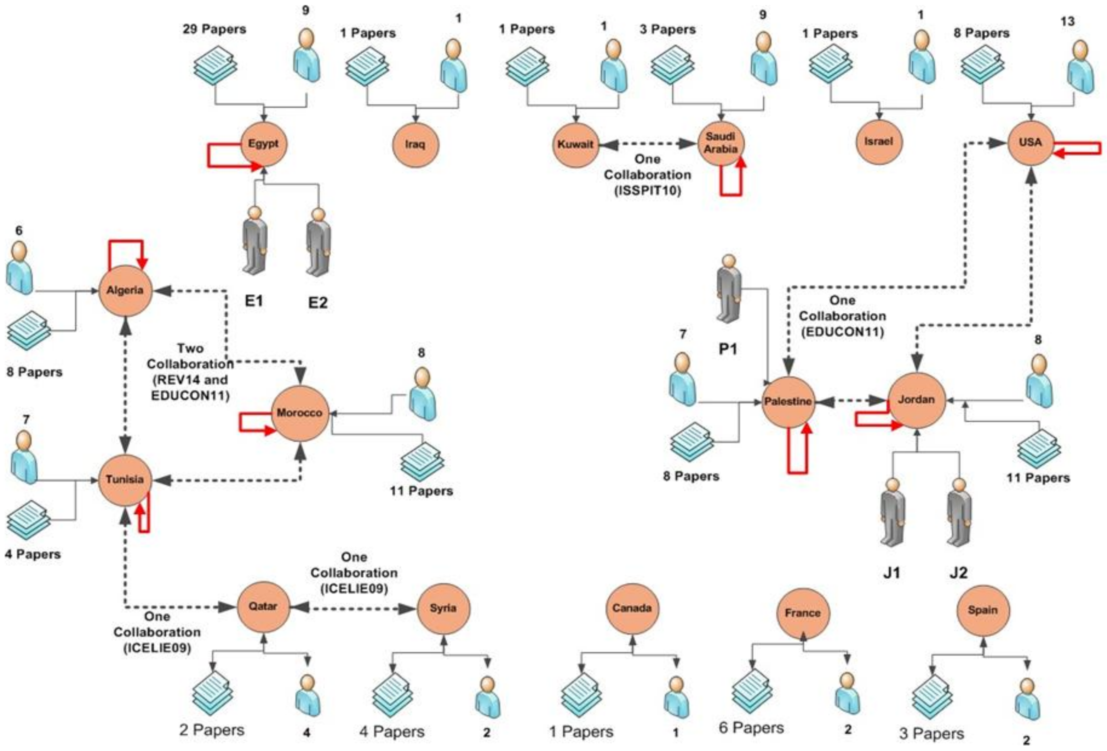


Figure 5.2: The Collaboration and Cooperation Work with the Number of Authors and Papers in the MENA Region from Conferences (REV and EDUCON), Journal (i-JOE), and IEEE Digital Library [103]

- **Techniques used for CIC:** This direction included meetings with global online labs communities, publishing papers, reviewing papers and online labs system techniques.
- **Techniques used for RNC:** This direction included online meetings and workshops, face to face meetings, and questionnaire techniques.

The next subsections detail the techniques that were used for building CIC and RNC networks.

5.3.2 CONTINENTAL AND INTERCONTINENTAL COMMUNITY NETWORK

As shown in figure 5.3, the techniques used to build a CIC Network were: Meeting Communities, Submitting and Presenting Contributions, and Reviewing Contributions.

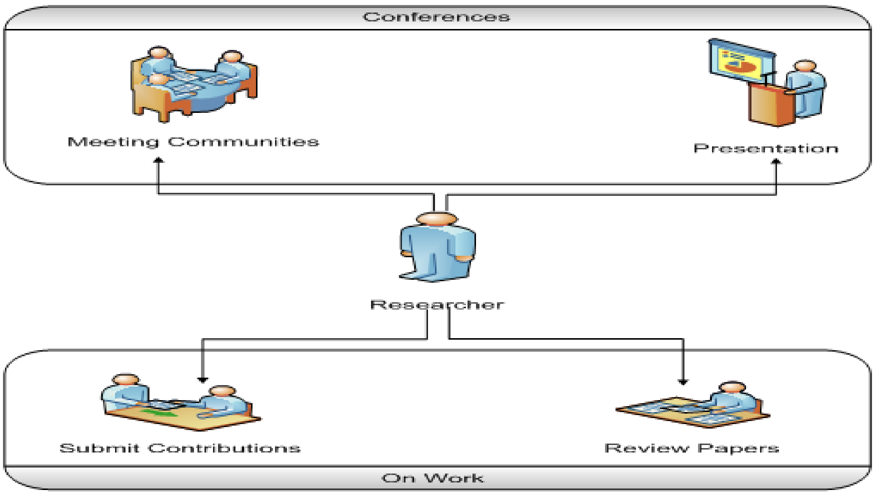


Figure 5.3: Building a Network with Continental and Intercontinental Community

- **Meeting Communities:** Several meetings took place during the author's participation in different conferences, namely ICEER2013, EDUCON2013, REV2014, and REV2016 conferences. The author became an interested and participating researcher in two CICs communities that are related to online labs fields, namely the VISIR SIG (see chapter 4) and the IEEE SA Collaboration via iMeet Central community.

- **Submitting Contributions:** Several contributions were submitted to different conferences and journals that are related to a community of practice around education and online labs, namely REV2014 [15], EDUlearn2015 [105], iCERi2015 [116], TEEM2015 [33] conferences, and the IJHCITP [103] and iJOE journals [108].

- **Presenting Contributions:** Presenting contributions in several conferences, namely ICEER2013, REV2014, EDUlearn2015, iCERi2015, and TEEM2015, was another technique used for building a network with CICs. This technique allowed the author to gain visibility in the associated research community. In particular, the presentation made at TEEM2015 is now publicly available in the YouTube video sharing website [i], which later supported the author's effort in presenting himself and his work in the area, to other researchers. This method helped to support the idea of creating a community of practice around online labs.

- **Reviewing Contributions:** After becoming part of the online labs community, as a part of the PhD work, the author has been invited to review papers. This technique allowed the author to read and follow recent and perspective ideas in online labs fields. Additionally, another task was evaluating one online lab system installed at the Federal University of Santa Catarina in Brazil, which is called RexLab [ii].

5.3.3 REGIONAL AND NATIONAL COMMUNITY NETWORK

Another direction was to build a RNC network. Different techniques for collecting data [98] were used for building this network, as shown in figure 5.4.

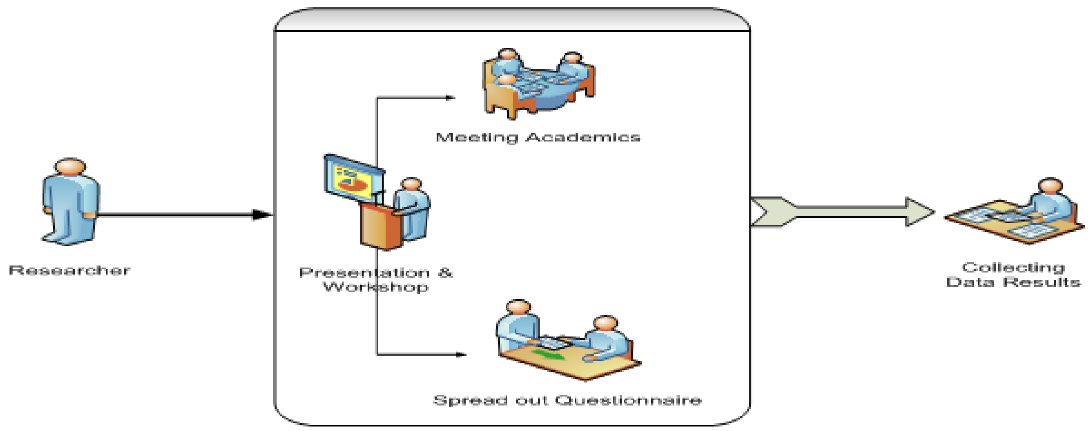


Figure 5.4: Building a Network with Regional and National Community

- **<u>Presentations and Workshops:</u>** For collecting data, the presentation, workshop, and online event meetings techniques have been used. These

---

[i] https://www.youtube.com/watch?v=K6Ql_khvJ44

[ii] In 2017, RexLab was awarded the best remote controlled laboratory by the Global Online Laboratory Consortium (GOLC). http://rexlab.ufsc.br/awards

techniques follow two other techniques: interview, and questionnaire. A series of presentations, workshops, and online event meetings were made about online labs at three institutions in Kurdistan Region-Iraq[i], namely University of Duhok (UoD), the University of Zakho (UoZ), and the Duhok Polytechnic University (DPU). 63 persons, out of a total 187 academics working in these three universities, participated in these events. These academics are specialized in electronics and computer engineering, physics, and computer science disciplines, as shown in table 5-1.

Table 5-1: Participating Universe from UoD, UoZ, and DUP

Universities	Total of Academics	Total of Attendees	Percentage from the University total	Percentage from the Universities total (187)
University of Duhok	102	31	30%	17%
University Of Zakho	55	21	38%	11%
Duhok Polytechnic University	30	11	37%	6%
Total	187	63	34%	

The 63 academics are classified as follows: 26 from Electronic and Computer Engineering, 14 from Computer Science, and 23 from Physics.

- ***Questionnaire technique results:*** This technique was used to collect the quantitative data by identifying and assessing the critical factors for the community of practice and inquired what materials and assistance are considered most important to help a higher education system (see annex I). The questionnaire has been transferred into a spreadsheet by putting each question number as a column heading, and one row for each person's answers, as shown

[i] http://uoz.edu.krd/news.php?NID=ODY=4ojboF5b

in table 5-2. It is scaled as follows: Strongly Agree, Agree, Disagree, and Strong Disagree [153][154]. This four-point scale, i.e. an even scale, forces people to choose a side, without a middle point [153][155]. It gives a certain tendency of answer, thus increasing the reliability and validity [156], and it is simple to use and generally well understood [157].

Table 5-2: Questionnaire Methods Result

Question Number	Scaling				Total Questionnaires	Percentage			
	(4)	(3)	(2)	(1)		(4)	(3)	(2)	(1)
Q1	6	40	12	5	63	10%	63%	19%	8%
Q2	14	42	6	1	63	22%	67%	10%	2%
Q3	14	37	10	2	63	22%	59%	16%	3%
Q4	20	32	11	0	63	32%	51%	17%	0%
Q5	11	46	6	0	63	17%	73%	10%	0%
Q6	19	37	6	1	63	30%	59%	10%	2%
Q7	19	38	6	0	63	30%	60%	10%	0%
Q8	17	37	6	3	63	27%	59%	10%	5%
Q9	15	39	7	2	63	24%	62%	11%	3%
Q10	20	33	10	0	63	32%	52%	16%	0%
Q11	27	28	8	0	63	43%	44%	13%	0%
Q12	13	39	11	0	63	21%	62%	17%	0%
Q13	6	34	22	1	63	10%	54%	35%	2%
Q14	3	18	28	14	63	5%	29%	44%	22%
Q15	10	45	6	2	63	16%	71%	10%	3%

- ***Interview technique results*****:** This technique was used to collect qualitative data by involving and interviewing several academics from these universities, individually, and asking them to answer six main questions that are focused on CoP, online labs usage, and education system, as shown in annex II. These academics hold a PhD degree and work at universities for more than 15 years. Some answers are presented next.

Q1: Can online labs technology provide useful information for teachers and students of higher education?

Commonly, the academics agree that online labs can provide useful information to students and teachers. They answered:

"It is very useful because it would provide experiments that cannot be available at the university using modern techniques" ***(Vice President, University of Zakho)***

"It could if we consider that teachers can have an overview into the already existed and ready experiments in its subject at the online lab system. For students, sure it would provide experiment information and can work on it from anytime and from anywhere" ***(Teacher in Electrical and Computer Engineering Department, University of Duhok)***

Q2: Do you think online labs technology can assist and support work of the teachers in the hands-on lab and, at the same time, offer students an easier way to complete their lab tasks?

Generally, academics approved that online labs can assist hands-on labs. They said:

"Undoubtedly, yes. Students will have a better understanding of their experiments if they have a chance to try it themselves utilizing online labs. The aim of teachers is to transfer the information and to get students practice experiments by their own, however, sometimes there is shortage of devices so each student would not have a chance to work practically by its own. Sometimes there is time limitation so the lab time may not be enough to complete the experiments. All these problems could hinder the process of transferring the information so online would help teachers and assist them

> *in this aspect."* ***(Teacher in Electrical and Computer Engineering Department, University of Duhok)***

> *"Online labs can support a hands-on lab by providing extra information and helps students to complete the equipments easily from anywhere, at anytime"* ***(Head of Physics Department, University of Duhok)***

One of the academics mentioned equipment's availability in online labs and the time available to complete the experiments by using online labs. He said:

> *"However it depends on the equipment's available. Also, it is very essential to know how long it takes to complete a task"* ***(Teacher in Electrical and Computer Engineering Department, University of Duhok)***

Q3: Do you think students may benefit from online labs technology applications, especially in STEM fields?

The academics totally agreed that online labs technology is helpful for STEM students. They said:

> *"The students can get the benefits of such a project, because they will get to information and achieve the task without any physical contact with the experiment"* ***(Vice President, University of Zakho)***

> *"Yes, both of teachers and students can get benefit from it. The teacher by using the new methods to develop his teaching and the students by connecting what they are studying with the current technology."* ***(Teacher in Physics Department, University of Duhok)***

In particular, it is possible to use online labs technology in countries that are facing a financial crisis. This was recorded by two of the academics who explained the financial situation now in Iraq. They said:

> *"Especially now where our province is in a financial crises" (Teacher in Electrical and Computer Engineering Department, University of Duhok)*

> *"It can be benefitted, especially for physics department due to financial constraints, hands-on labs in our department cannot include all components*

for students to complete the experiments" ***(Head of Physics Department, University of Duhok)***

Q4: Do you think online labs technology can improve the curricula in higher education system?

Several academics clarified why online labs technology can improve curricula. They explained it can improve curricula by sharing costly equipments with worldwide universities. Here is one answer as an example:

"Sure, because higher education system requires several equipment and tools that might not be available. Therefore, such a technology will compensate such lack of availability". ***(Vice President, University of Zakho)***

One academic highlighted a main point related to the number of students. He said:

"It depends what facilities are available? Can we use this technology to conduct our laboratories keeping in mind that the number of students is high?" ***(Teacher in Electrical and Computer Engineering Department, University of Duhok)***

Q5: Do you think online labs technology can increase collaboration and cooperation works among researchers?

The academics believe online labs have the ability to increase the collaboration and cooperation work among researchers. In addition, more motivation is needed in order to use them in STEM fields. For example:

"To my knowledge, it will. However, it needs some more motivation and encouraging researchers and even students to use such a technology. This can be implemented by giving presentations and doing a lot of practicing" ***(Vice President, University of Zakho)***

"It will help to increase the collaboration and cooperation work by create using online labs. This technology can help to create a bridge for researchers to share information and knowledge" ***(Head of Physics Department, University of Duhok)***

"The systems would let researchers and people from the academia share their knowledge and experience. So, this would be a great opportunity to collaborate and share information and work together" ***(Teacher in Electrical and Computer Engineering Department, University of Duhok)***

Q6: Finally, do you have a special advice on how to use online lab technology in STEM fields?

The two main advices that were recorded during the interviews are:

"On-line labs can provide good alternative for some educational establishments (probably in third world countries). From my own experience the issue of labs is quite complicated. In most cases labs and their equipment needs logistic support. By this I mean a range of things, starting with fund for the initial cost, right personnel to run and maintain the equipment, suitable premises and last but not least (the legitimate use of these lab equipment (in some cases). These could be burdensome responsibilities for some educational establishments. In the online labs case most of these issues are resolved. As a computer laboratory can play a dual functionality in these cases, besides being a computer lab it could be used as Electrical Technology (for instance) using online labs via internet connection" ***(Head of Refrigeration and Air Conditioning Department, Duhok Polytechnic University)***

"I suggest the following to use the online lab. The first step is to encourage the staff members and postgraduate students to use this technology. It is important to introduce them to the facilities and devices available. The second step is to use this technology to implement final year projects. The third step is to encourage all undergraduate students to use this technology" ***(Teacher in Electrical and Computer Engineering Department, University of Duhok)***

- **Online Meeting:** It should be mentioned that some questions have been asked by the audience during an online presentation as well. This session was organized by Prof. Gustavo R. Alves[i] from the Polytechnic of Porto, School of Engineering (IPP-ISEP). He responded to the questions that came from the audience. We present a brief summary with some of the most relevant questions and answers:

  Q1 : Why are online labs free?

  Answer: The purpose of online labs is educational. Its use is for assisting and supporting hands-on labs, not to replace them.

  Q2 : How can online labs increase the collaboration and cooperation work among researchers?

  Answer: Online labs have the ability to increase collaboration and cooperation works by sharing the resources, experiments, etc., among researchers.

  Q3 : Do online labs have the ability to create a CoP?

  Answer: Yes, today, there are communities around online labs, for example VISIR. This community is called a Special Interest Group (SIG) and it includes many researchers from different countries.

  Q4 : Is it possible to consider that online labs can be one of the useful options for government, in case of unavailability of equipments, or high-cost of instruments?

  Answer: In general, it can be said that online labs save time and money. Therefore, yes, online labs can be used, in case of unavailable equipments or costly equipment, for assisting hands-on labs. Additionally, it can help to develop the students' technical skills and contribute to the quality of higher education.

---

[i] https://scholar.google.com/citations?user=vAonlVMAAAAJ&hl=en

5.4 RESULTS ACHIEVED

FIRST ACHIEVEMENT: Include Experiments into the VISIR Node:

The initial achievement was including a few experiments for three universities (i.e. UoD, UoZ, and DPU), from Kurdistan-Region in Iraq, into the VISIR system that is installed at IPP-ISEP, in Portugal. These universities and their students can run the experiments remotely. Additionally, these experiments are controlled by the teachers from those universities. In fact, the methods used to build RNC supported this achievement.

As shown in figure 5.5, the scenario for creating the initial community of practice included three levels. The first level was connecting universities (Service and Receive Experiment “SRE”): University (A) offers the experiments to serve the teachers and students of university (B). The second level was making a bridge among researchers and teachers of those universities for sharing the resources and materials of the experiments. The third level was opening online experiments that could be used by the students of both universities. This achievement led to a project proposal for building a community around online labs with other researchers abroad, as described in the next paragraph.

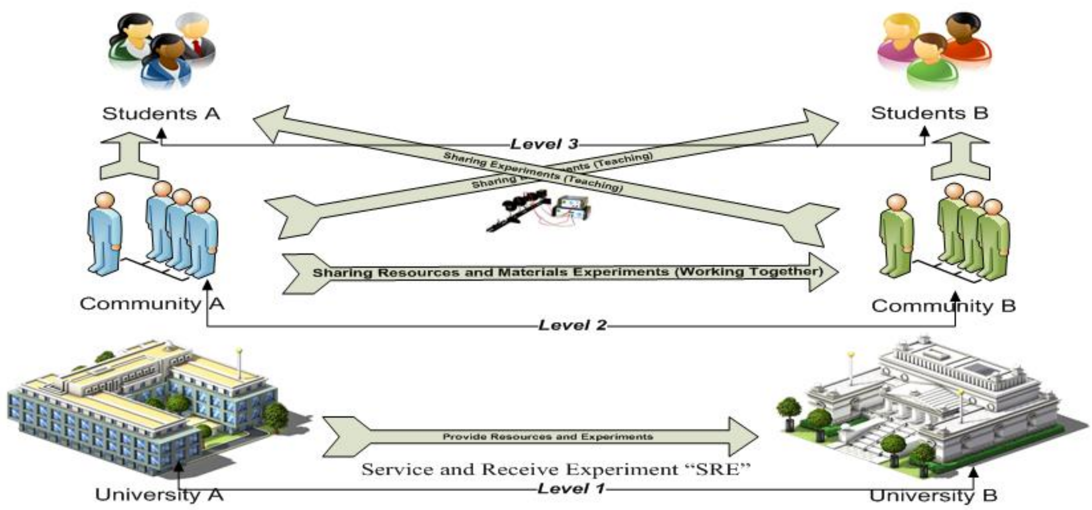


Figure 5.5: Scenario for Creating the Initial Community of Practice (Sharing Experiments)

SECOND ACHIEVEMENT: IREX Project

The second achievement was submitting a project proposal to the International Research & Exchanges Board (IREX[i]) organization (see chapter 7). The project idea is to build a network among Iraqi universities and United States universities through remote experimentation for serving teachers and students in higher education. This project is entitled "*Building a Remote Experimentation Network for serving higher education teachers and students in Iraq (REXNet)*". The project was selected for funding by IREX and allows leading United States universities to administer exchanges with other world regions. A group of researchers and teachers from different universities in Kurdistan-Region in Iraq have been participating in this project. The host United States University gave a training course for several academics in the Kurdistan-Region, Iraq.

MAIN ACHIEVEMENTS: Building a Community of Practice around Online Labs

After building the CIC and RNC networks, we can state that a new community of practice around online labs, serving the MENA region, has been created. The first one, the community of practice members are becoming partners in VISIR open labs project by adding several experiments. The second one involves some researchers at UoD, UoZ, and DPU in the IREX project to participate in a training course at the Oklahoma State University. The researchers are collaborating with a group of the Virtual Reality lab and Cyber Learning at Oklahoma State University. The primary idea is focused on collaboration work among researchers and help to develop a strong foundation by involving the creation of innovative educational and research programs, which support the development of remote STEM courses. This idea can allow students to work

---

[i] IREX is an international non-profit organization providing thought leadership and innovative programs to promote positive lasting change globally. It enables local individuals and institutions to build key elements of a vibrant society: quality education, independent media, and strong communities. https://www.irex.org/

remotely, as a team, and to use equipment for supporting STEM educational activities, as shown in figure 5.6.

Currently, at the Kurdistan region, in Iraq, the beginning of a community of practice around online labs will cover different disciplines from different universities (e.g. Electric and Electronics Engineering, Computer Engineering, Physics Science, and Computer Sciences). Hopefully, this community of practice can help improving the higher education system in the Kurdistan region, especially, and in Iraq, in general. It can add a value to educational curricula, via active learning activities, by sharing experiments among universities. Additionally, it will increase the collaboration and cooperation work with other universities and academics from the region and abroad, especially in STEM fields.

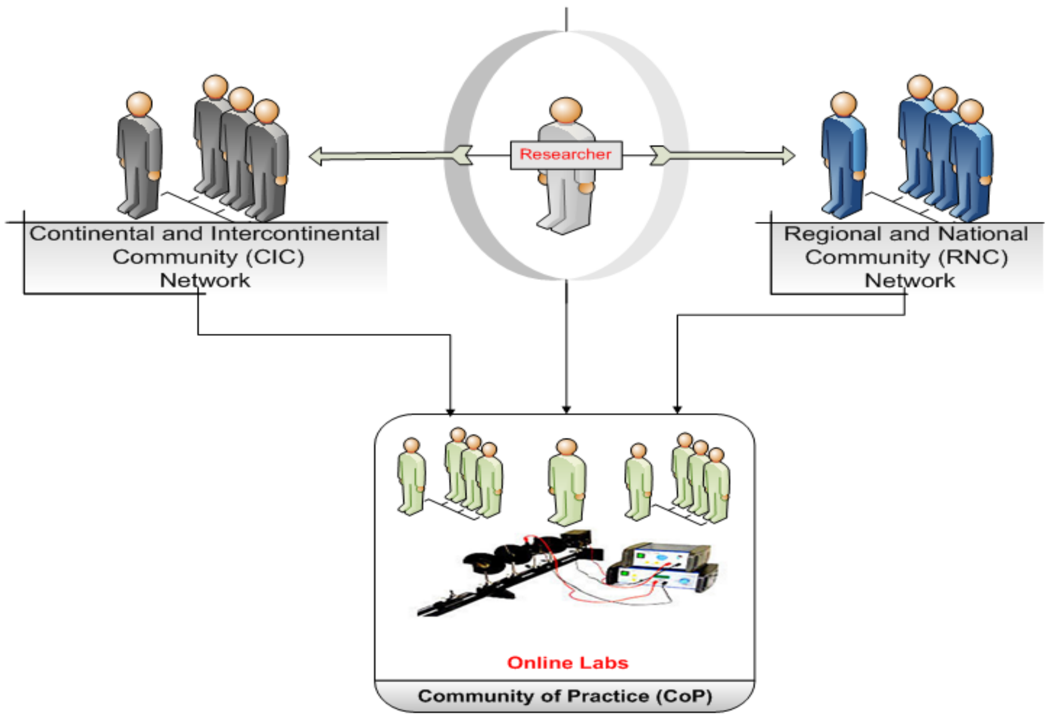


Figure 5.6: Community of Practice around Online Labs

5.5 CONCLUSION

Education is fundamental to development and growth, in any country or region in the world. Still, in many places, the higher education systems are not yet fit for the twenty-first century. Among these, some are located in the MENA region. Furthermore, the education systems in this region are facing several challenges, especially in STEM fields. These challenges have been impairing the achievements of students. It is possible that these challenges have prevented producing a broad human capital base and have resulted in lowering economic and social development. In general, this chapter provided obvious implications for the education systems in the MENA region and it highlighted some points that may assist the education systems in this region.

Nowadays, education sectors must have support for the long term, not just for the present. In particular, science and engineering faculties must have different teaching methods and include active learning techniques for increasing the collaboration and cooperation work among teachers and students.

Additionally, use of technologies in education systems, i.e. online labs, helps to improve education systems and to create a community based on it. Therefore, the major objective of this work was to create a community of practice around the use of educational technologies. Furthermore, it is an optimal time for creating a community of practice around online labs in the MENA region, especially in STEM disciplines. This objective may provide a boost to teachers and students to become accomplished and skilled in their fields.

Finally, we hope that, by setting the online labs technology indicator, this work may be used as a guide for developing higher education systems in other regions. Similarly, it must also uncover other indicators that have a wider impact to develop and assist the higher education sector and to support the environments of collaborative and cooperative work among researchers.

In brief, it is possible to summarize this chapter with the following words, taken from a Cisco white paper on “How Technology can transform Higher Education in the United States” [158]:

> *“Yesterday's teaching methods are not consistently effective for students today and tomorrow. In a world that is increasingly digital and connected, many students have a low level of engagement in traditional educational settings.”*

"I slept and I dreamed that life is all joy. I woke and I saw that life is all service. I served and I saw that service is joy"

Kahlil Gibran (1883-1931)

CHAPTER 6.

ONLINE LABS FEDERATION

Abstract

Web-Based teaching and learning methods have proved their efficacy in schools and universities by extending traditional instruction into active learning and motivating students to engage in science exploration. These methods, which include the use of online labs, are allowing users to benefit from technology-enhanced educational tools with both hardware and software parts. Today, online labs are becoming a good means to teach scientific theory and practice to students, in STEM fields.

To guarantee prosperity, the world needs skillful people and educational institutions, specialized in science and engineering disciplines. Therefore, several worldwide collaborations among researchers have been created around the subject of online labs, for example Go-Lab and VISIR. These projects are starting to federate, in order to allow teachers and students to more easily find remote experiments and efficiently apply them in their curriculums.

6.1 INTRODUCTION

Simply, education is a foundation of modern society, because it provides the power to the human being for developing civilization and culture. Furthermore, it is a key factor in developing the human communities and enhancing the economy of nations. In fact, developing education and human resources can be regarded as a precondition for accelerating the pace of economic growth and development. The value of education and its effectiveness in supporting sustainable development should be increasingly recognized [159].

Education systems have become extremely complex and multifaceted. This led to several challenges when considering their reform and improvement. Presently, several countries in Europe have been developing their educational system, particularly in science and engineering fields. For instance, the initial British educational system of engineering was based on a system of apprenticeship, and then evolved to become more based on technologies. Later, Britain recognized the close connection between engineering, science and mathematics and therefore reshaped its education system to be based on engineering sciences. Some other countries in continental Europe developed their own educational systems, based on French and German models, which are founded on science and mathematics. As a result, science and engineering education have become an increasingly more relevant activity, that is based on instructional technologies, gaining the attention of many scholars in the United States and in European and Asian countries [160].

In other words, regarding these phenomena, many countries still face critical challenges for ensuring the high quality of STEM education, for instance countries in the MENA region. These countries still need to create opportunities for investing in its educational system as required [15][103].

Education technologies refer to the use of hardware, software and applications, as a tool, in educational settings for advancing teaching and learning. These technologies can provide students with information, achievements, and capacities for life-long learning that are necessary for the 21st century workplace [161]. For example, the National Education Association report published at the United States in 2008 issued several recommendations to improve education, aim at such goals. One of these recommendations was to integrate technologies into schools and classrooms, as stated [162]:

> *"To improve students' and educators' access to technology in the classroom (or primary work place), as well as outside of the school, by providing more wireless and portable technology." (pp. 6)*

Great strides in technologies have infused additional information and activities into education and the instructional process. Many universities worldwide have invested in inserting technologies in their education systems and in their educational infrastructures. These technologies have provided the educational system with resources and software, for students and staff, and established curriculums that are based on technologies, in order to ensure that students can achieve a high level of competency before they graduate [163]. Furthermore, several universities have federated themselves by using these technologies [164], in particular online labs. In a nutshell, a federation of online labs is important for increasing the number of possible experiments accessible to students and leverages its resources within other countries, such as the MENA countries, for sharing experience and assisting them to develop their educational system [33].

This chapter aims to present possible ways to create an online labs federation that provides pedagogic added value to students, teachers, and education systems. The federation concept is presented in section 2. Section 3 presents a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of online labs, and then discusses the need for an online labs federation. This section also includes a brief explanation and examples of online labs federation models that have been suggested by other researchers. A new scenario of an online labs federation for VISIR is also particularly addressed. Section 4 describes the online labs federation outcomes, in the short, medium, and long terms, and how such a federation can assist other countries, especially in the MENA region. The chapter conclusions are presented in section 5.

6.2 WHAT IS A FEDERATION

In general terms, a federation is a union of several smaller parts that perform a common action [165]. Federations share advantages and challenges among its members for providing advice and support to its members and to the public [166].

Under the education umbrella, the technical term "federation" refers to a user's ability to login to multiple data (i.e. applications, resources, experiments, materials) with a single authenticating point [167]. This idea resembles the federation concept in the context of a configuration database [168], as defined by BMC Software defined [169]:

> *"Federation is a method to provide a single way to access data held in many different locations. Federation allows data users to search and utilize data without needing to understand exactly where the data resides or the technology behind accessing the data." (p.2)*

Likewise, in 2008, Sun Microsystems Corporation explained the federation concepts in its online book [170], in the following terms:

> *"Federation establishes a standards-based method for sharing and managing identity data and establishing single sign-on across security domains and organizations. It allows an organization to offer a variety of external services to trusted business partners as well as corporate services to internal departments and divisions. Forming trust relationships across security domains allows an organization to integrate applications offered by different departments or divisions within the enterprise as well as engage in relationships with cooperating business partners that offer complementary services."*

The concept of a federation comprises two aspects: identity federation and provider federation. Identity federation is a set of information by which one person is definitively distinguished. Provider federation is a circle of trust that includes a group of service providers for exchanging authentication information [170], as shown in figure 6.1.

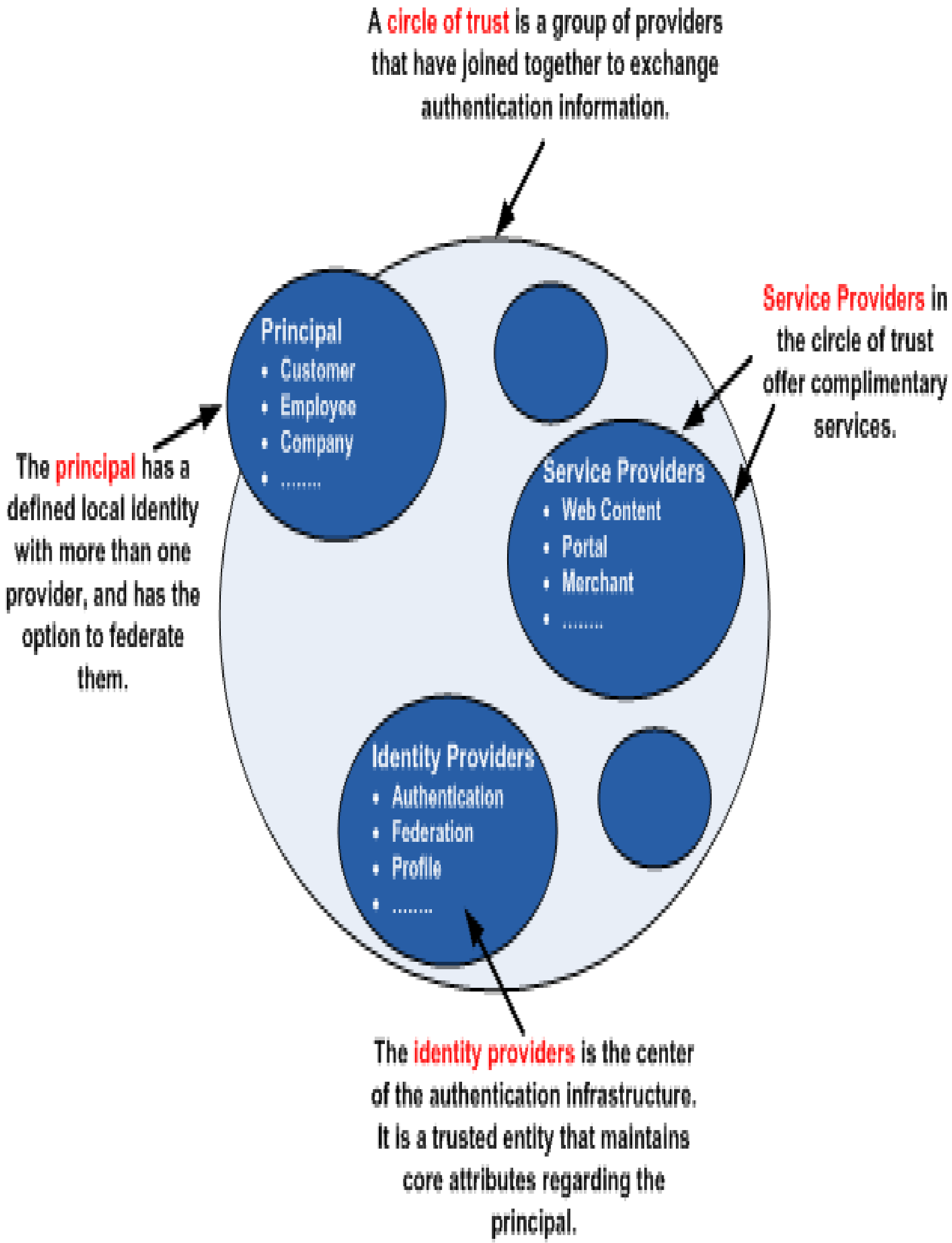


Figure 6.1: Subjects Involved in an Identity Federation (as taken from Reference [170])

6.3 WHY IS AN ONLINE LABS FEDERATION NEEDED?

In general, online labs provide a range of flexible learning options. They allow the students and teachers to engage into their study, attain their goals, and advance their professional careers, in situations where physical learning resources are scarce [171].

One can first use a SWOT matrix to identify the internal and external factors affecting online labs, as shown in table 6-1. SWOT is actually an acronym that stands for strengths, weaknesses, opportunities, and threats.

Table 6-1: SWOT Matrix (2*2)

	Positive	**Negative**
Internal	Strengths	Weaknesses
External	Opportunities	Threats

SWOT analysis is a simple and useful technique for understanding and analyzing the factors that influence a given system. This process can offer powerful insight into the potential and critical issues affecting online labs, in order to gain some perspectives of its consequences [172][173], as shown in table 6-2:

- ***Strengths:*** Internal factors that have a positive effect on (or are an enabler to) achieving objectives.
- ***Weaknesses:*** Internal factors that have a negative effect on (or are a barrier to) achieving objectives.
- ***Opportunities:*** External factors that have a positive effect on achieving objectives.
- ***Threats:*** External factors that have a negative effect on achieving objectives.

Table 6-2: SWOT Matrix Applied to Online Labs

	HELPFUL	HARMFUL
INTERNAL	***Strengths*** • Increase the competences of the teachers, develop the skills of the students, aim at academic excellence and quality of work by learners. • Share resources, offer services. • Bring together people with different academic backgrounds.. • Increase the collaboration and cooperation work among researchers. • Involve new universities that are willing to participate (opens doors). • Lead Community of Practice (CoP) engagement, diversity and inclusiveness. • Pick up a strategic objective (development of new services for users and develop their abilities).	***Weaknesses*** • Teachers not available often enough and lack of diversity among staff and students (restricted interactivity). • Need enough time for maintaining the experiments and following up the courses (technological reliability). • Not all staff members have the same knowledge to employ services. • Limited reach to experiments (time effort).
EXTERNAL	***Opportunities*** • Develop new collaborative models. • Cultivates Community of Practice (CoP) talent and grow its size. • Create multiple programs (increased enrollment; increase the resources and materials). • Build a successful generation by attracting young people to science and engineering (students with fresh technology and ideas; helps to think out of the box). • Resolve problems (receive highest rating for operations).	***Threats*** • Keep students away from real labs. • Increase the cost (budget constraints). • Users limitation (weakening affiliations). • Fund cuts or reductions. • Lack of resources which causes a lack of communication. • Materials are not of high quality.

6.3.1 CREATING AN ONLINE LABS FEDERATION

Over the past few years, some projects, for instance Go-Lab, have presented a repository to serve students and teachers worldwide [174][175]. This was a step in the right direction towards setting up an online labs federation. The fundamental principle of the Go-Lab project is to create a pedagogic framework for inquiry-based learning, provide access to experiments for users, worldwide, and build a group of communities for teachers, students and researchers to facilitate collaborative work among them. On a second phase, Go-Lab started to aim for an online labs federation supported by the European Schoolnet[i]. This online labs proto-federation comprises 19 organizations from 12 countries and is coordinated by the University of Twente, from the Netherlands [176].

Several online labs federation models have been proposed for sharing laboratories, for instance the iLab Shared Architecture (ISA) and the Labshare Sahara. They are based on Simple Object Access Protocol (SOAP) Web Services [177]. Essentially, there are two different modes of access to experiments [178]: *batch experiments mode*, which is based on queues, and *interactive experiments mode*, which is based on a booking system. ISA supports both modes [179][180], while Labshare Sahara supports interactive laboratories only [177][178].

Conceptually, the Service Broker is a backbone component of the ISA model [179][180][181][121]. The main feature is that ISA has been designed as an one-to-one vehicle, meaning the receiver university cannot share the remote experiments with other universities that are outside the federation boundaries. The Labshare Sahara model has the same main feature, as ISA. However, the ISA and the Labshare Sahara models do not support load balance among the federation nodes, i.e. the possibility of distributing the accesses to experiments in a way that is transparent to the remote clients [164].

---

[i] http://www.eun.org/home

6.3.2 RECENT PHD WORKS ON THE ONLINE LABS FEDERATION IDEA

Several researchers have been working on the idea of an online labs federation. In some cases, the work is based on the VISIR Open Lab Platform. Among these, we count two recent PhD projects, which analyse the question of how to create an online labs federation and also why such federation is needed.

- **Pablo Orduña's work [164]:**

In 2013, Pablo Orduña, a former PhD student at University of Deusto in Spain, addressed the idea of sharing a laboratory in his PhD thesis. Orduña said:

> *"A unique characteristic of remote laboratories when compared to traditional laboratories is that the distance of the student to the real equipment is not an issue, so remote laboratories can be shared with other institutions. One entity can share a laboratory to other entity." (pp.15)*

In this statement, Orduña uses the term entity to refer to either an university, a school, or a research center. Elsewhere, in this thesis, Orduña observes that sharing a laboratory can be managed in a simple way. The provider entity where the equipment is located can provide the laboratory to the users by creating an account for them. In this respect, the main challenge is to create and manage the user accounts of all other foreign universities. To handle this problem, he suggests applying the federation idea to online labs. He recommends the participating universities should have the same software framework for managing the shared laboratories, as shown in figure 6.2.

As a result, an online labs federation does not require the provider universities to manage students and courses of the client entity, but it allows them to track all the users requests submitted to the provider universities. The main advantage of this federation architecture is that it can provide the load balancing of users accesses to the same exact remote laboratory. This load balancing, proposed in a VISIR scenario, is shown in figure 6.3. Moreover, a VISIR federation can support distributed load balancing of users accesses to available experiments, and the students and teachers can use one login credential for all available experiments inside the federation.

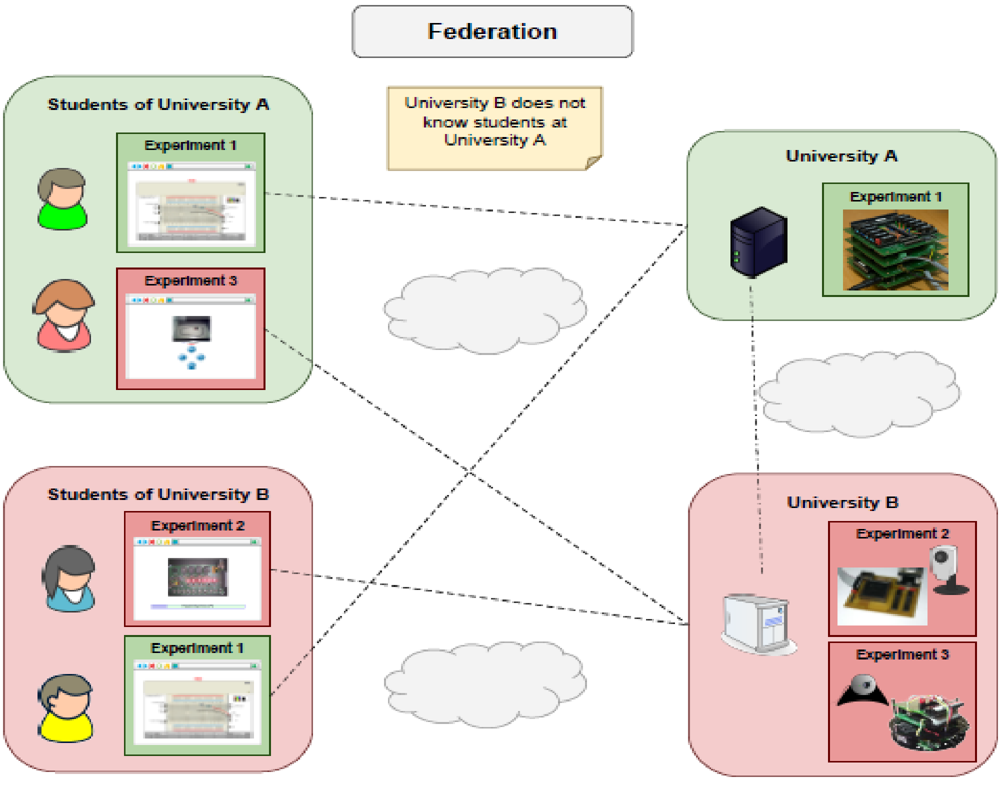


Figure 6.2: Federated Remote Laboratories, as Proposed by Orduña (as taken from Reference [164])

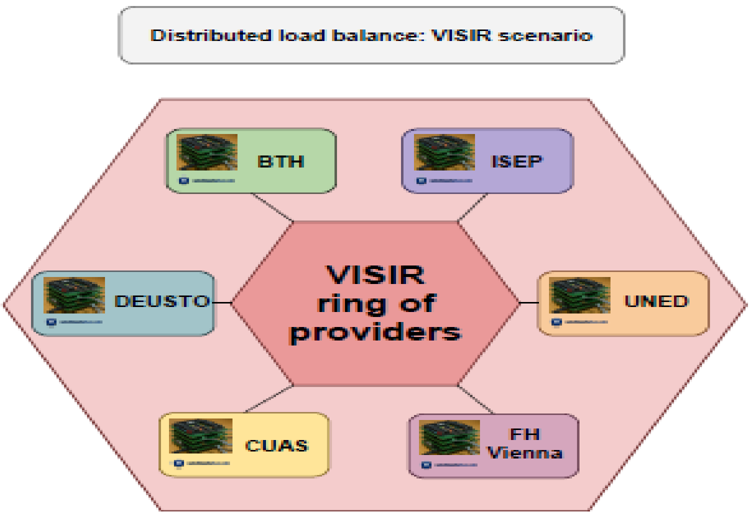


Figure 6.3: Ring of VISIR Providers (as taken from Reference [164])

- **Mohamed Abuelela's work [123]:**

In 2013, Mohamed Abduelela, a student from Egypt who obtained a PhD at the National University of Distance Education, in Spain, discussed the idea of sharing resources and remote labs among universities in the course of his PhD work. He highlighted that it is possible to share remote labs by using Remote Laboratory Management Systems (RLMSs), as shown in figure 6.4. Abduelela wrote:

> *"A RLMS is a Web application that provides a common online portal for accessing and administrating a wide pool of heterogeneous remote lab systems that might be distributed across different institutions and geographical locations." (pp.145)*

> *"Currently, for a remote laboratory that is provided by one institution to be accessed by users from a different institution, typically those users must directly access either the laboratory itself or the providers RLMS (if one exists)." (pp.153)*

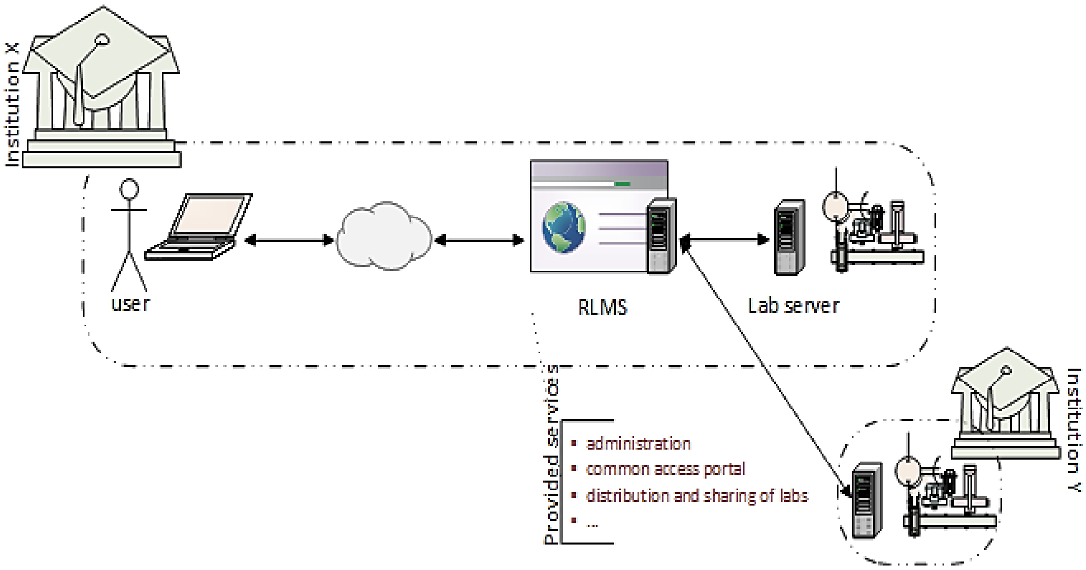


Figure 6.4: Architecture of RLMS (as taken from Reference [123])

Abduelela discusses the features of an RLMS in details. He argues that RLMS can include a set of tools to encourage the creation of a communication framework among different institutions for sharing online experiments. One of the communication scenarios presented by him is between the Massachusetts Institute of Technology (MIT) and the University of Technology Sydney (UTS). Abduelela comments that such a communication framework must be supported by an agreement between institutions to allow sharing experiments among them through an API, or it could be called a standard Remote Laboratory System Interface Specification to support system-to-system communication, as follows:

"It would be possible for the UTS user to gain access through Sahara to experiments installed at MIT and integrated in ISA if there is an agreement between both institutions and as long as both architectures support this standard interface in order to interconnect with each other." (pp.153)

Thus, for this paradigm, RLMS at MIT can provide access to its remote experiments to both MIT and UTS students and vice versa, as illustrated in figure 6.5. This scenario implies using Single Sign-On (SSO) technologies to create a federation of remote labs among institutions and allows all students to access and perform all remote experiments, located within the federation [167].

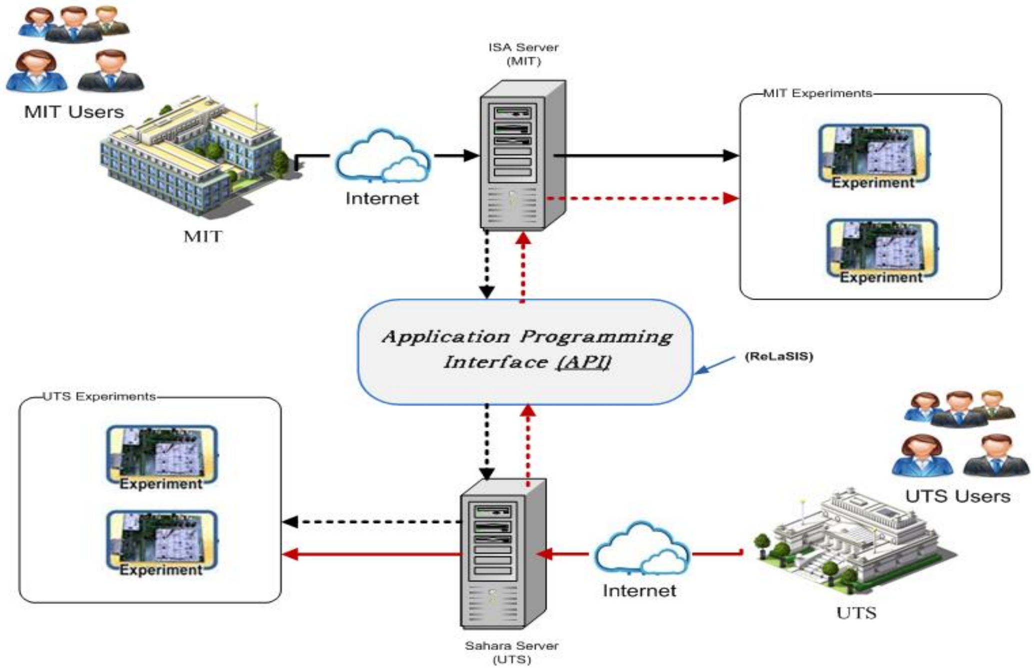


Figure 6.5: Sharing Remote Experiments between MIT and UTS by Using API

6.3.3 A VISIR OPEN LABS PLATFORM FEDERATION: PROPOSED SCENARIO

Nowadays, the VISIR Open Labs platform has been installed in ten institutions worldwide. These nodes are distributed in seven countries [105][116] (see chapter 4). In this scenario, a VISIR federation can manage the load balancing among the several existing and future VISIR nodes, i.e. the nodes that are being set up in Brazil and Argentina, under the scope of VISIR+ project [182]. In the next paragraphs, we explore two scenarios: a set of VISIR nodes with and without a federation.

No Federation Scenario

As shown in figure 6.6, each university (A, B, and C), with an installed VISIR node, can provide and use the online experiments. Other universities (X and Y), which do not have an installed VISIR node yet, can only use the online experiments.

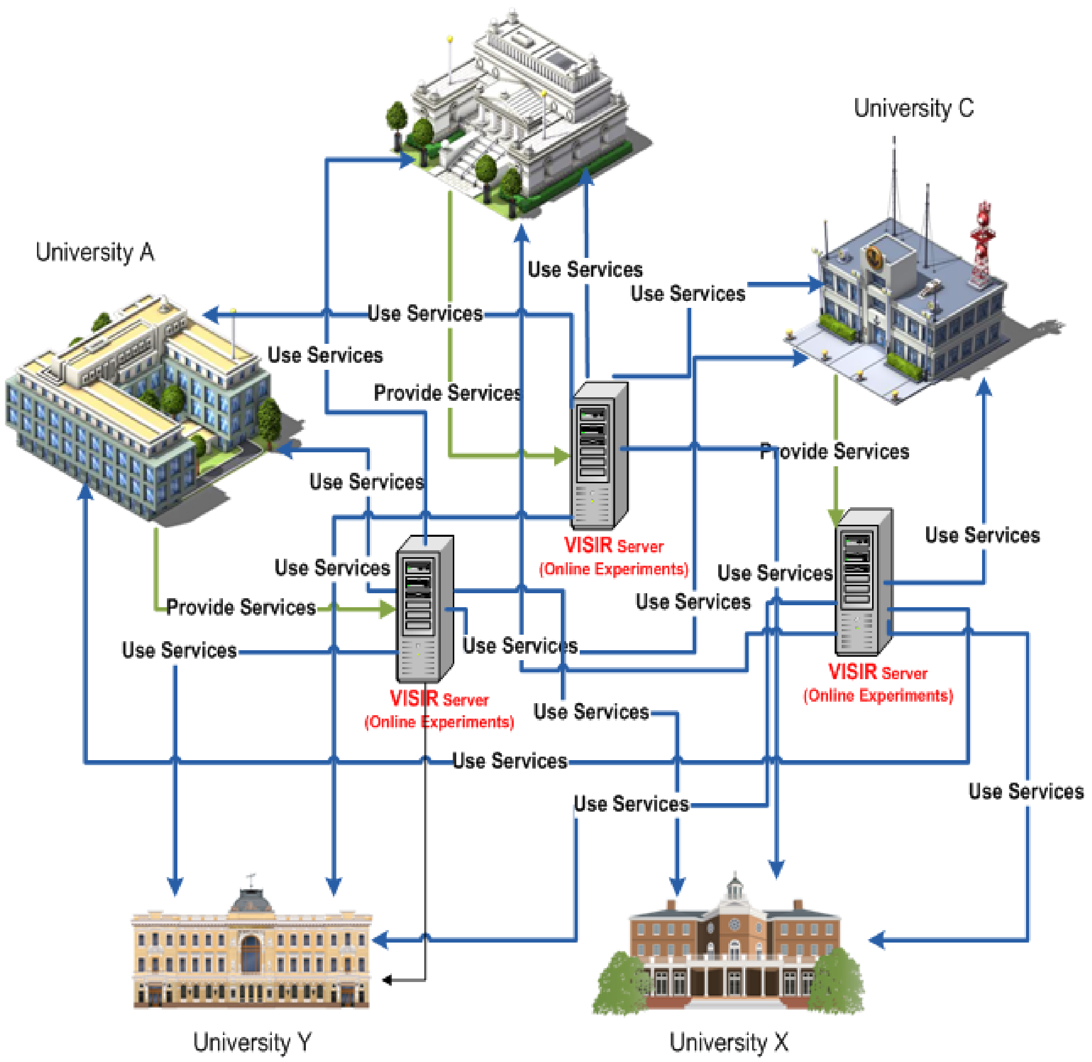


Figure 6.6: Online Labs (VISIR Experiments) among Institutions without a Federation

The users from each VISIR node can have access to its experiments by using their login credentials, which are verified by the system server. If a user from one VISIR node would like to access other online experiments, or the same experiments, from another VISIR node, then he will need to use a different login credential, as illustrated in figure 7. These two figures (6.6 and 6.7) explain the scenario of several existing VISIR nodes and user access to VISIR experiments without a federation.

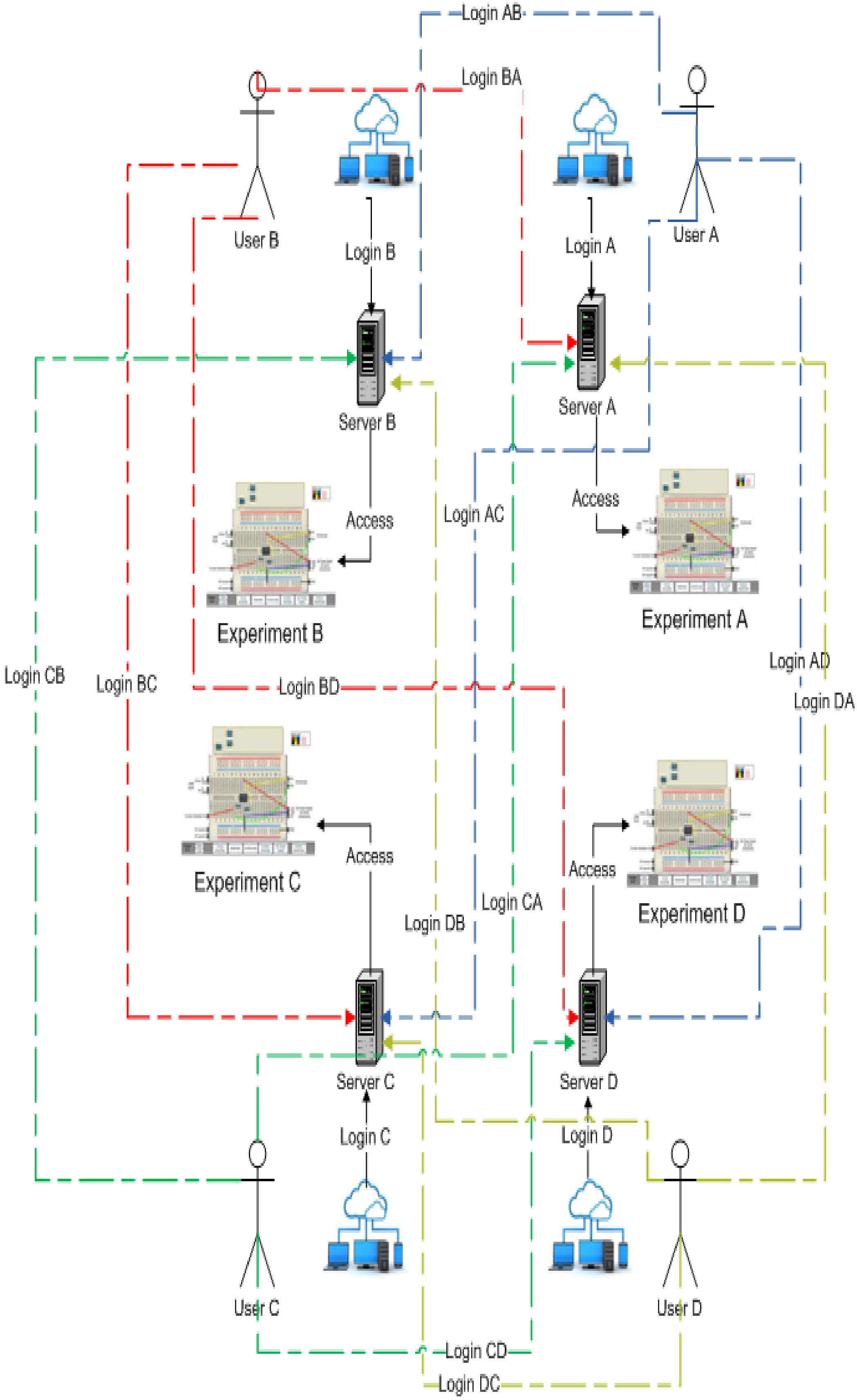


Figure 6.7: User Access to Online Labs (VISIR Experiments) without a Federation

Federation Scenario

In general, the architecture of an online labs federation is based on software services (e.g. Single Sign-On "SSO"). This software can allow a user to access multiple systems with one set of login credentials, as shown in figure 6.8.

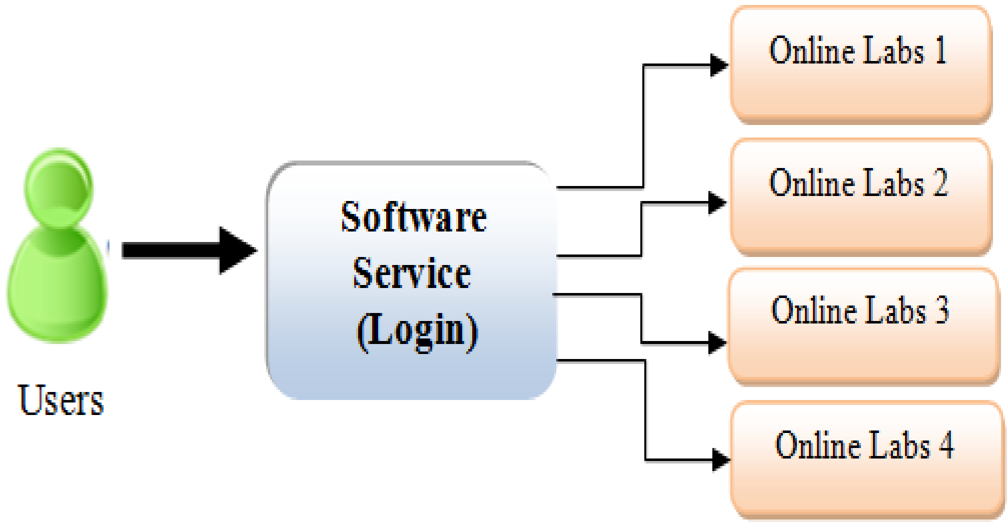


Figure 6.8: Online Labs Federation Architecture

Figure 6.9 illustrates the scenario of a VISIR federation. In simple terms, the universities (A, B, and C) can offer online experiments (Provide Experiments) inside the federation for their students and for outside students. At the same time, each university can access other online experiments (Use Experiments) that are provided by other universities. This federation allows students and teachers to use one login credential, instead of different login credentials. Furthermore, it can distribute the number of queued experiments (Batch mode) between two or more VISIR nodes for balancing the users access (Load Balancing).

Other universities (X and Y), who are part of the federation, but have no installed VISIR node, can still use online experiments (Use Experiments), inside the federation as well, but with different login credentials that are verified by the system servers.

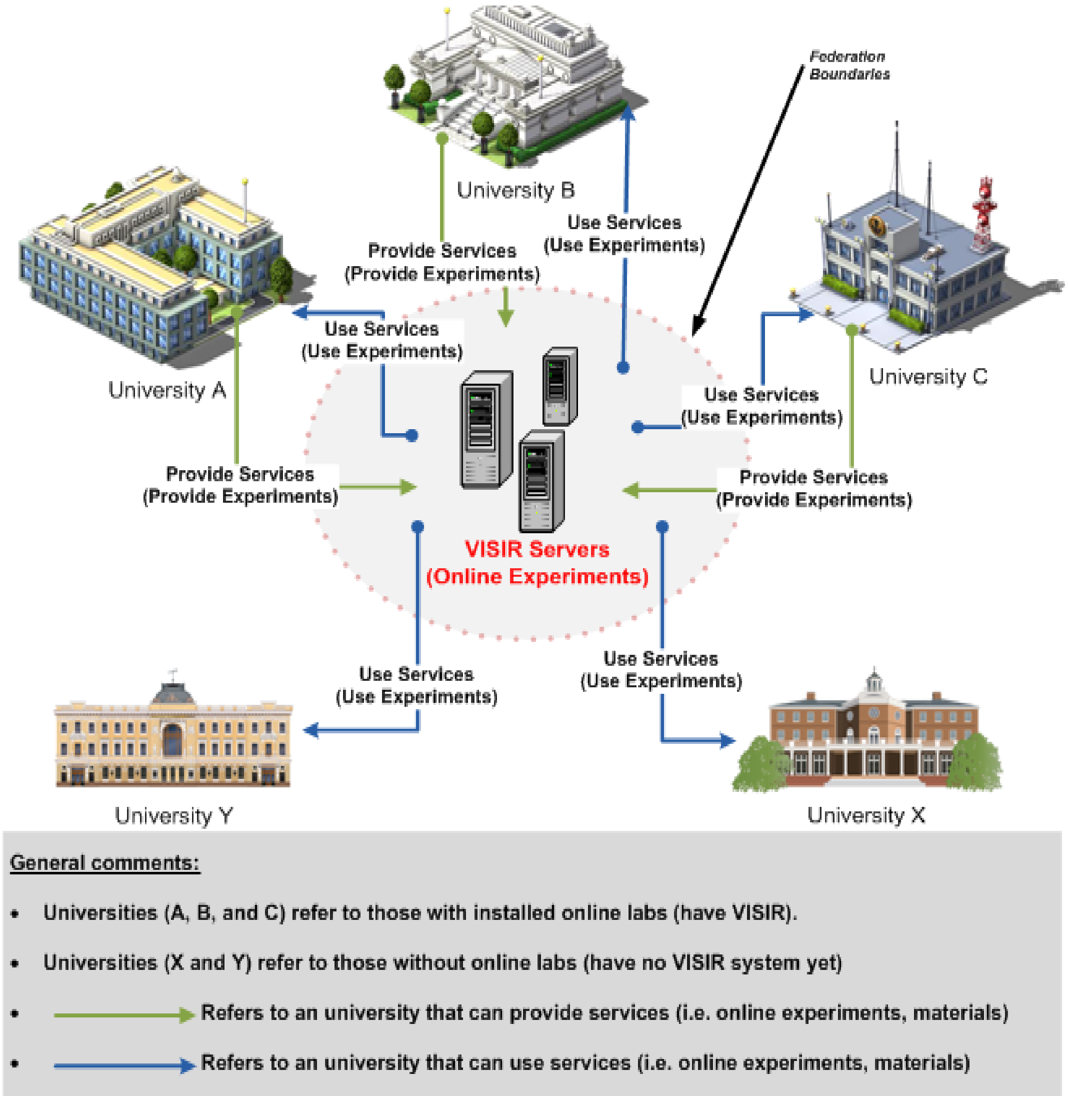


Figure 6.9: Online Labs (VISIR Experiments) among Institutions through a Federation

Figure 6.10 shows how the users access to the VISIR experiments, which are located and run on somewhere, by using one login credential. In sum, a VISIR federation can be useful for universities for balancing the students' accesses, without access overload, through all VISIR nodes by sharing their experiments and materials. This figure gives the idea that some experiments, for example experiments A, B, C, and D, can be different, while some other experiments, for example experiments X and Y, can be the same, which means these same experiments can be located in two or more different VISIR servers. A recent paper [183] compared the run-time of one experiment in one VISIR node, under different user accesses scenarios. It concluded that time response when running several experiments grows with the number of user accesses. In the experiment that was reported the number were as follows: a unique user may wait between 52-64 milliseconds to receive the result, 5 simultaneous users may wait between 200-400 milliseconds, and 20 simultaneous users may wait between 2090-2100 milliseconds. Therefore, it is up to a software layer to distribute the user accesses to experiments X and Y, in order to implement load balancing and reduce the delay in getting the results of an experiment.

Load balancing is especially important for the VISIR federation because it is responsible for handling the user requests that will be issued to each server and forward user requests to another VISIR node by maintaining session persistence in the event that one or more servers become overburdened or unresponsive. Moreover, a VISIR federation can provide scalability and availability for VISIR nodes by periodically monitoring the VISIR node servers and evenly distributing loads across these servers.

Furthermore, a VISIR federation can involve other universities who are installing a VISIR system to also benefit from its additional services (Single Sign-On "SSO" and load balancing).

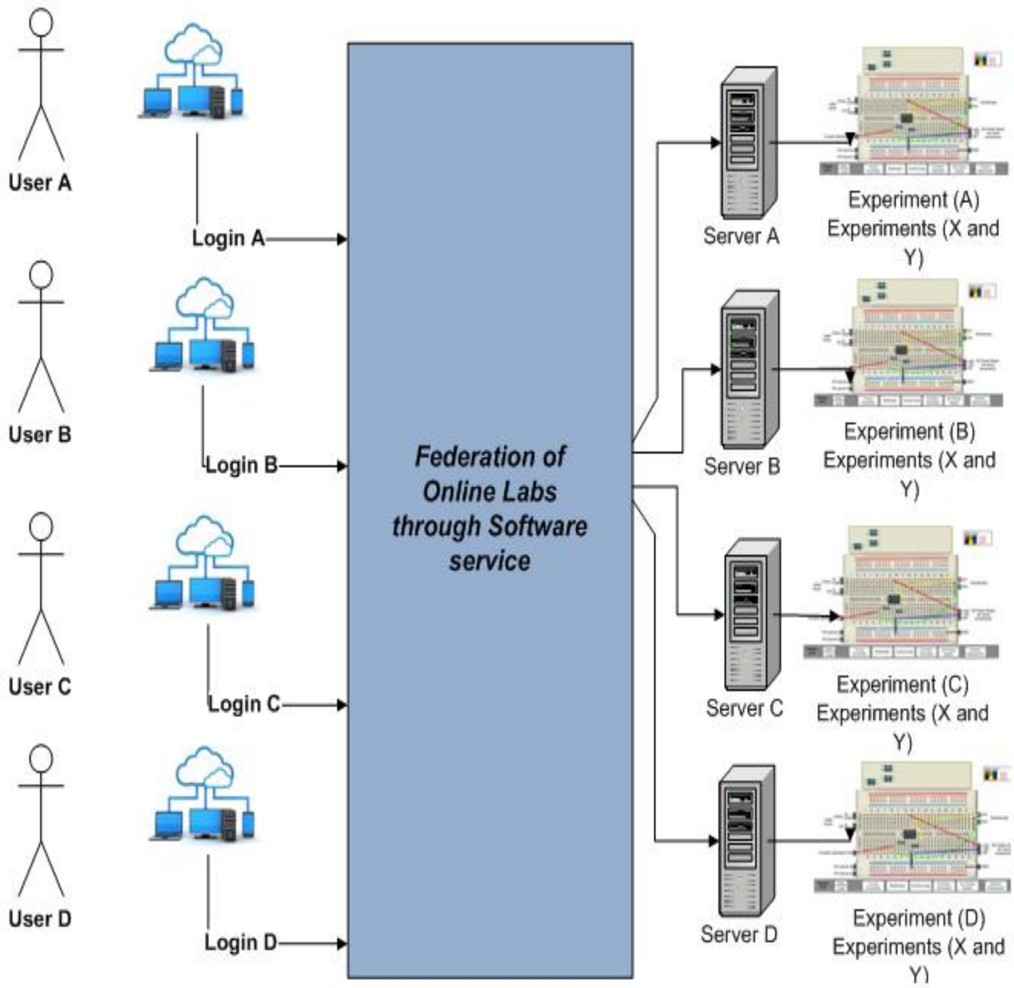


Figure 6.10: User Access to Online Labs (VISIR Experiments) through a Federation

6.4 ONLINE LABS FEDERATION OUTCOMES

Broadly, building an online labs federation, particularly for VISIR open labs, has several possible outcomes. These outcomes are described according to what difference can an online labs federation make, in the short term, in the medium term, and in the long term [184][185], as follows:

6.4.1 SHORT-TERM OUTCOMES

- Forming the union of several online labs systems to perform a common action.
- Deploying and managing the other external and internal services to match the needs.
- Offering more opportunities to students for performing experiments in learning spaces.
- Increasing the sharing of resources and good practices.

6.4.2 MEDIUM-TERM OUTCOMES

- Inviting new universities from other countries and regions to join this federation, after installing VISIR in their institution, for extending the size by providing-receiving more experiments and services.
- Promoting the collaboration and cooperation work between local and global researchers.
- Improving the educational system quality, investing in university and faculty development, and developing the students skills and teachers competences in practices and technical methods.
- Encouraging young students to engage in science topics, to acquire scientific inquiry skills, and to do science under motivating circumstances.
- Increasing the workforce knowledge and skills.

6.4.3 LONG-TERM OUTCOMES

- Developing strong links among VISIR nodes to balance the experiments in electric and electronics fields.
- Developing the services to better meet users' needs.
- Collecting information about VISIR nodes that can be used in the future.
- Increasing the workforce knowledge, and skills of partnerships.
- Benefiting from more agreements outside their federation.

6.5 CONCLUSION

In general, a federation refers to an interaction among systems for the purpose of facilitating communication. As a software component, it can provide the users with Single Sign-On (SSO) access to systems located across organizational boundaries.

In the past few years, online labs tended to focus on: what online labs do, what experiments must be included, and who can access the experiments (*who will be served?)*. In some online labs projects (i.e. VISIR and Go-Lab) we can learn about what has been accomplished through research papers by people involved in those project, and also via the new project proposals that are being made.

However, a federation can transparently map several online lab systems to a single federated entry point. In other words, an online labs federation is aimed to interconnect multiple systems via a computer network, which can be centralized or decentralized geographically. Therefore, this idea can help to federate the online labs systems by providing a uniform interface and enabling users to store and retrieve the experiments data from multiple sources.

In this endeavor, the overall purpose of an online labs federation is to coordinate and balance the users accessing to online experiments from different nodes. The federation can help institutions to develop their systems applications and promote international programs and publications in the area of online labs. Therefore, this chapter focused on describing the idea of an online labs federation in general, and partially of the VISIR federation. It aims to provide a model of the VISIR federation by using standards-based federation technologies (e.g. RLMS and Single Sign-On “SSO”). Effectively, this online labs federation can enhance the learning and practical training at universities by developing several electric and electronics remote experiments, with real components, that can be shared among those universities and with other universities who have no VISIR system installed yet. Furthermore, it can help tracking the users accesses for balancing the experiments requests.

To summarize: an online labs federation allows developers to scale up the software developments efficiently and handle proportionally service levels, with no significant drop in cost effectiveness. In addition, it can balance multiple users accesses to the available online experiments inside the federation, through load balancing. Finally, by enabling software service such as Single Sign-On (SSO), an online labs federation allows users to access multiple systems with a single username and password and then access to experiments without being prompted to login again. This is a solution that enables users to login once.

To conclude, an online labs federation motto could be:

- ❖ One experiment for all students (Load Balancing).
- ❖ All experiments for one student (Single Sign-On).

"I am an ordinary man who worked hard to develop the talent I was given. I believed in myself, and I believe in the goodness of others"

Muhammad Ali (1942-2016)

CHAPTER 7.

DISCUSSION OF RESULTS

Abstract

Nowadays, online labs have become a type of E-learning in developed countries, especially in science and engineering fields. They are considered a key educational resource that can assist and support hands-on labs and develop students' practical skills. Currently, several countries (e.g. Europe and United States) are using online labs in the curricula extensively. On the other hand, some countries (i.e. MENA countries) still lack the use of instructional technologies in their curricula, particularly online labs. Therefore, it is possible to invite the MENA countries to use online labs for developing students' practical skills, establishing bridges among teachers and researchers to increase collaborative and cooperative work, and enhancing their higher education systems.

7.1 INTRODUCTION

In fact, the education environment is focused on how the students may have broad prospects for learning and on what can help them achieve their learning objectives. It encourages them to connect with the real practical environment, especially in science and engineering domains.

So far, higher education systems in the MENA region still need to reshape for developing student's skills and extending collaborative and cooperative work among researchers [15]. Therefore, for updating the higher education systems of the MENA region it is necessary to include new instructional technologies that allow their students to have access to more information than ever before.

Importantly, for overcoming the challenges of higher education systems in the MENA region that exist now, the major strides of this dissertation are: (i) extending and integrating online labs, in order to add more services and functionalities, especially in science and engineering disciplines; (ii) increasing collaborative and cooperative work among teachers, researchers, and students in the field of educational technologies, by creating a CoP around online labs; and (iii) preparing an initial platform for the MENA countries to become a part of an online labs federation in the short future. These strides are starting from the Kurdistan-region of Iraq.

Overall, this chapter is focused on results up to date and their validity in this dissertation. The structure of this chapter is as follows: Section 7.2 details the results to date and their validity. Section 7.3 presents the work evaluation. Section 7.4 discusses the work. Section 7.5 describes the expected impact. Section 7.6 concludes the chapter.

7.2 RESULTS TO DATE AND THEIR VALIDITY

Knowledge of science allows people to think logically and solve problems, i.e. to have "problem-solving skills". Furthermore, it allows them communicate with each other for learning and understanding other subjects better, for developing ideas, and for inventing new technologies [186].

During the work of this dissertation several tasks and activities were already completed, for example several conference papers and journal articles were published, there were successful collaborations with other researchers, one project proposal was submitted, students from different countries were supervised, a new VISIR node was installed, etc. This section highlights the results that are validated and that scaffold this work.

7.2.1 CONTRIBUTING RESULTS

During the course of this PhD work, several contributions were published in international journals and conferences, namely: iCEER13, REV2014, EDULEARN2015, iCERi2015, and TEEM2015 conferences and IJHCITP and iJOE journal. In addition, one contribution has been submitted to a book edition on higher education [i].

Also, a recent book published in 2016 and edited by Mahmoud Abdulwahed, Mazin O. Hasna (both from Qatar Universities, Qatar), and Jeffrey E. Froyed (from Texas A&M University, United States), focused on education systems in the MENA region. This book, named "Advances in Engineering Education in the Middle East and North Africa", cited the REV2014 conference contribution [15] in two different chapters, chapter 10 and 16 [187]. For example, Jennifer DeBoer, the author of chapter 16, refers that online labs can offer more opportunities to access resources and facilitate university networks in the MENA region [134], stating that:

> *"Using remote labs may also facilitate university networks and consolidation in the Middle East and North Africa."(pp.386)*

7.2.2 COLLABORATION RESULTS

During the collaboration with other researchers in the online labs field, specifically VISIR researchers, the open source code -*Web Interfaces*- of the VISIR was translated to Arabic and Kurdish languages and became available online. Then, it was also

---

[i] This book is a self-contained collection of scholarly papers targeting an audience of practicing researchers, academics, PhD students and other scientists.

(https://www.intechopen.com/welcome/98977ad0f9bc0a5224a23d6f67b343ca) translated to Polish and Dutch during the supervision of two Erasmus students from Poland and the Netherlands, who did their internships at ISEP, Porto- Portugal.

In result, a new VISIR node has been installed with these additional languages at the Polytechnic of Porto- School of Engineering (IPP-ISEP). This node aims to be available to MENA universities, and others, for serving their students.

7.2.3 SUBMITTING A PROJECT PROPOSAL

At the end of 2015, the IREX organization offered an opportunity to Iraqi universities for presenting project proposals aimed at promoting their development. After several steps (e.g. online meeting, filled application form, contacted United States universities partners), an initial project proposal submitted by a group of researchers from Duhok universities in Kurdistan region-Iraq, has been finally accepted for implementation and funding. The general idea of this project is to use online labs to build a remote experimentation network for serving higher education teachers and students in Iraq.

7.3 WORK EVALUATION

This section reviews the results that have been achieved from the beginning of 2013 untill the middle of 2017. In general, online labs can serve thousands of students around the world. They can be integrated in LMS and other social network applications.

Today, online labs are considered as a service for creating multiple opportunities to teachers and students by offering the best possible experiments with multiple modules [188][189][190]. Currently, MENA countries have a new opportunity to support their higher education systems by using online labs. This opportunity can help the MENA countries to increase utilization of devices and share resources among their teachers and students.

7.3.1 VISIR OPEN LABS FOR SERVING ELECTRICAL AND PHYSICS COURSES

As mentioned above, IPP-ISEP has installed a new VISIR node for deploying service-oriented experiments to global university and, especially to the MENA countries[i]. This node is starting to serve universities in Iraq (i.e. Kurdistan region universities), as shown in figure 7.1.

Currently, this node is going to serve three universities from the Kurdistan region, in Iraq, namely University of Duhok (UoD), University of Zakho (UoZ), and Duhok Polytechnic University (DPU), in the 2016-2017 academic year. It will include several experiments (e.g. Ohm's Law and Kirchhoff's Law) for serving electrical and physics teachers and students. In result, the teachers, researchers, and students can collaborate to share the results and knowledge among them.

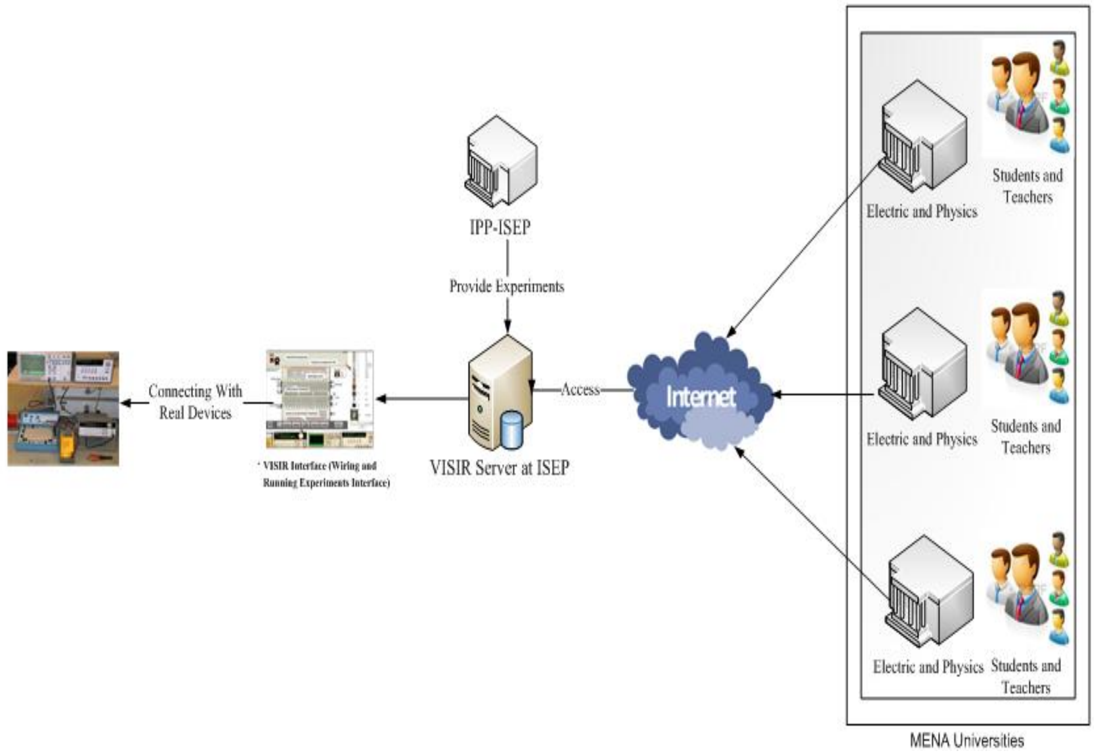


Figure 7.1: A general Architecture of a New VISIR Node at IPP-ISEP for Serving the MENA Region Universities and Institutions

[i] http://193.136.60.179:8080/Home/Details?name=VISIR%2B

7.3.2 VIRTUAL REALITY BASED LEARNING ENVIRONMENT FOR COMPUTER SCIENCE COURSES

Virtual Reality Based Learning Environment (VRLE) is a virtual lab that is recently available to Iraqi universities under the scope of the REXNet project[i]. This project results from a proposal submitted to the IREX organization. It aims to serve higher education teachers and students in Iraq by including several modules of experiments, which have been developed by the Oklahoma State University (OSU) in the United States.

Basically, as shown in figure 7.2, these modules are comprised of learning components called Virtual Learning Environments (VLEs). VLEs are considered one of the most promising of next generation cyber learning approaches. Finally, this project will be available to teachers and students from the three universities from Kurdistan mentioned above in the 2016-2017 academic year.

Likewise, this project can be viewed as another opportunity to the MENA universities for increasing collaborative and cooperative work among their researchers and developing students' skills, especially in computer science disciplines.

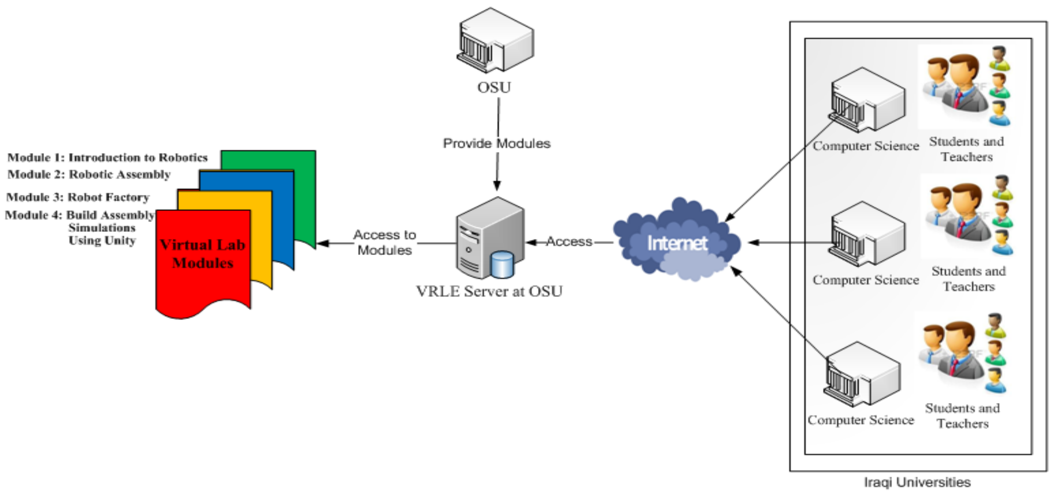


Figure 7.2: A General Architecture of the REXNet Project at OSU for Serving Iraqi Universities and Institutions

---

[i] http://tinyurl.com/jtf96m3

7.3.3 COMMUNITY OF PRACTICE AROUND ONLINE LABS

A series of presentations were made in three universities in Iraq, University of Duhok (UoD), University of Zakho (UoZ), and Duhok Polytechnic University (DPU), especially in science and engineering areas. In result, a small CoP around online labs was created in the Kurdistan region of Iraq. The members of this CoP are from science and engineering disciplines of those universities. This CoP will be important for serving higher education system of Kurdistan, by promoting online experiments by students, based on VISIR and REXNet. Furthermore, its members can collaborate together to do other activities such as research work, developing experiments, and submitting other project proposals in the short future

7.3.4 ONLINE LABS FEDERATION

The Erasmus+ program, supported by the European Commission, awarded a new project proposal, namely "*Platform Integration of Laboratories based on the Architecture of visiR* (PILAR)" [191]. The PILAR project responds to development needs of interactive practices with electrical and electronic circuits in the area of science and engineering. Furthermore, it aims to include a comprehensive set of practices serving different needs, different academic levels at school and college. In general, the objective pursued by PILAR is to build a unique VISIR platform federation by integrating VISIR resources from five VISIR partners, Blekinge Institute of Technology (BTH), Carinthia University of Applied Sciences (CUAS), University of Deusto, Oporto Polytechnic Institute (IPP), and National University of Distance Education (UNED).

In result a VISIR federation can present several advantages for the MENA region, for instance: i) creating links between the MENA region and VISIR partners, in educational areas, for strengthening higher education; ii) allowing MENA teachers and students from science and engineering fields to do a greater number of experiments; and iii) giving support to the MENA institutions in case they are interested in acquiring and installing a local VISIR node.

7.4 WORK DISCUSSION

It could be said that the higher education systems (institutions, teachers, and students) in the MENA countries are benefiting from: 1) using online labs, 2) participating in a CoP around online labs, and 3) the perspective of joining an online labs federation. For serving higher education systems and increasing collaborative and cooperative work among researchers in the MENA region, the idea is to connect technologies (i.e. online labs), community of practice, and online labs federation. This idea can help serving learners with different educational backgrounds, perspectives, life experiences, and ways of thinking about a solution to a difficult problem, to come up with more creative solutions, etc.

- **Using online labs:** As a result of this PhD work, MENA universities (particularly in Kurdistan region-Iraq) have an additional opportunity to gain access to online resources, especially in science and engineering education. As shown in figure 7.3, these additional online resources are available through VISIR and REXNet. We believe this is a way to keep students engaged and continuing to pursue essential professional skills.

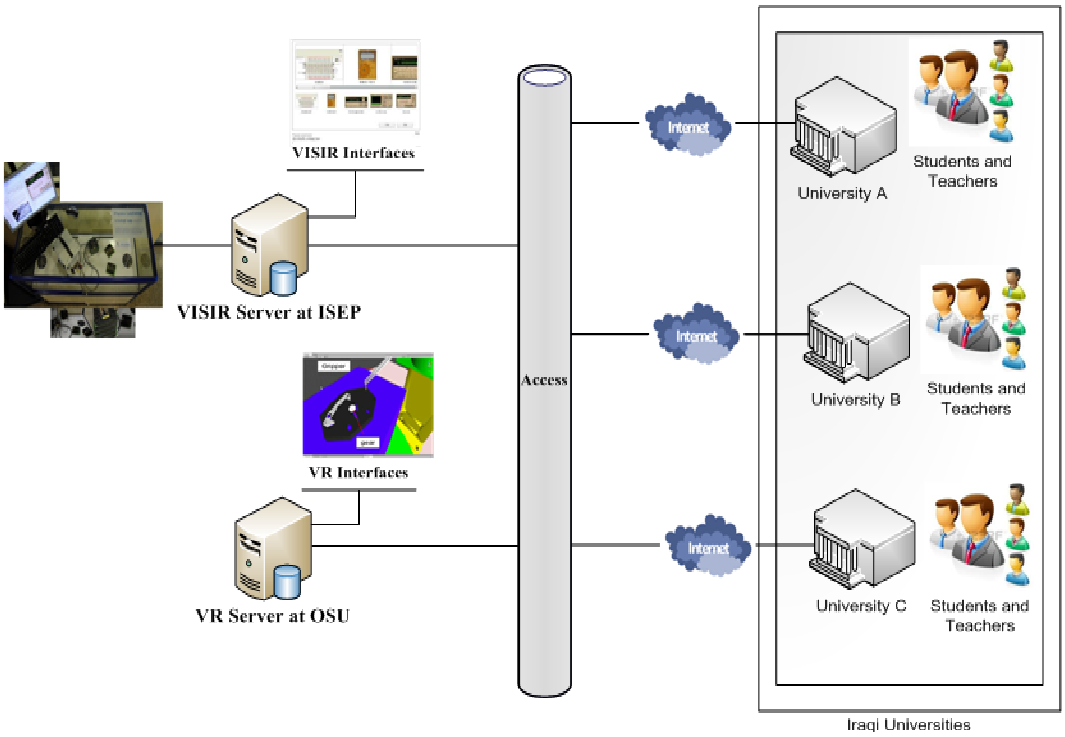


Figure 7.3: A General Framework of Access to VISIR System and REXNet Project

- **Creating a Community of Practice Around Online labs:** In particular, a CoP has been created for gaining knowledge related to online labs. A CoP can help learners to come together for sharing resources, creating new knowledge, and becoming novice workforces in the practical researching and higher education systems development.

- **Federating VISIR:** Finally, a VISIR federation can offer additional opportunities to perform scientific experiments with online labs in pedagogically structured learning spaces and share its resources and materials with other teachers, students, and researchers abroad. In addition, it enables other countries, such as MENA countries, to install a VISIR node and become a part of the VISIR federation in future.

7.5 EXPECTED IMPACT

Nowadays, education can benefit from technology-enhanced tools to develop methodological skills, investigation through experimentation, teamwork and communication among teachers and students through collaborative activities. Therefore, the rapid development of ICT has invaded the educational process by providing learners with several opportunities to face challenges in education, especially in STEM fields.

In recent years, online labs have proved their efficacy in education, especially in science and engineering domain, by allowing teachers and students to perform their tasks and experiments through the Internet, and increasing their motivation [114].

Additionally, online labs aim to offer more experiments relevant to the students' educational field. The online experiment should be as interesting and as effective as the traditional, hands-on, ones. Furthermore, they allow learners to access educational materials from different locations 24 hours a day, 7 days a week, in order to foster their knowledge, as much as possible [33].

Summing up, this study focused on:

1. Determining the level of higher education systems in the MENA region.

2. Seeking solutions that can contribute to the quality of higher education systems in the MENA region.

3. Creating a CoP around instructional technologies, based on online labs, in the MENA region.

4. Preparing a base platform to the MENA region for becoming a part of online labs federations (e.g. a VISIR platform federation) in future, especially in science and engineering disciplines.

Finally, we believe that these achievements can help enhancing the higher education systems in the MENA countries, in general, and in Iraq, in particular.

7.6 CONCLUSION

In recent decades, several countries and regions have been following the strategy of increasingly using instructional technologies in their higher education systems for supporting teachers and students. Currently, instructional technologies, for instance online labs, have proven easy to use and scalable tools. They constitute a new kind of service-oriented resource for serving teachers and students by providing educational materials, called "*online experiments*", especially in science and engineering disciplines.

Today, the MENA region can follow up the same strategy, which exists now in United States, Europe, and other regions, for supporting their higher education systems and developing the teachers and students skills. In our view, there are three factors that can assist the MENA universities, which could be named as a three factors (3Fs) model. These factors can enhance higher education systems in many ways and support collaborative and cooperative work among MENA researchers in STEM fields as well, as detailed in below:

- **Instructional Technology "*Online Labs*":**

    - Make online labs easy to access for students and teachers from the MENA region.

- **Community of Practice around Online Labs:**

- Create a MENA-based research group for meeting researchers abroad in the field of online labs.

Online Labs Federation "*VISIR federation*":

- Facilitate the access of MENA universities to an online labs federation by collaborating with other universities.

Finally, the implementation of this 3Fs model has been at the core of the present PhD work, aiming to provide an answer to each one of three research questions laid down in chapter 3.

"My Life Is My Message"

Mahatma Gandhi (1869-1948)

CHAPTER 8.

CONCLUSION AND FUTURE WORK

Abstract

There is a present challenge in reshaping higher education systems, especially less developed ones as found in the MENA region. The main purpose of this dissertation is to determine solutions for assisting the higher education systems in this region. To accomplish that goal it is necessary to reach some prerequisite, namely, to increase the collaborative and cooperative work among the MENA researchers in the field of instructional technologies (e.g. online labs). Online labs are widely used for supporting teachers and students in STEM education, for example VISIR. Likewise, the proposed community of practice around online labs aims to make online labs not just accessible and free-charge to students, but mainly to equip them with the necessary skills to be productively employed in future. Finally, development activities of an online labs federation (i.e. VISIR federation) can allow faculties to stay abreast of the latest updating and best training practices in this area. A federation can create an optimal environment for teachers and students to acquire important new knowledge and skills, especially in the MENA region.

8.1 INTRODUCTION

Reifying, the target problem and objectives were described and contextualized in the introduction of this dissertation. The main target is to propose a solution for enhancing higher education systems in the MENA countries and increasing collaborative and cooperative work among their researchers.

Nowadays, online labs (*as VISIR, CHAPTER 4*) have proven themselves as a good means for assisting hands-on labs and increasing collaborative and cooperative work among researchers. Therefore, the new VISIR node installed at IPP-ISEP can be used for raising collaborative and cooperative work among the MENA researchers for science and engineering disciplines, especially courses that require experiments with electric and electrical circuits.

Furthermore, building a network of regional and national communities *(as a CoP around online labs, CHAPTER 5)* allows creating a relationship between researchers from the MENA region and other researchers from outside this region. Therefore, a community based on online labs can bring their experience to the MENA institutions, share knowledge and resources among the MENA researchers, and enhance the MENA teachers' skills.

Essentially, an online labs federation *(as a VISIR federation, CHAPTER 6)* provides several possible outcomes to students. For example, it can offer more opportunities to students for performing experiments from different nodes, increasing the sharing of resources, etc. Therefore, other institutions (e.g. MENA institutions) can benefit from this federation through multi-access to VISIR nodes and become a part of this federation after installing a VISIR system in the future.

Overall, this chapter closes the dissertation by providing the outcomes, problems and limitations, recommendations based on its results, and future directions for other researchers from the MENA region or abroad who are interested in the online labs field. Finally, it also concludes the work.

8.2 MAIN THESIS OUTCOMES

The present study offers suggestive evidence and arguments for reshaping the higher education systems in the MENA countries by integrating additional instructional technologies in their teaching and learning process. On the face of it, this would increase the collaborative and cooperative work among teachers and researchers in this region. Based on the lack of materials often available for educators in the MENA institutions, the study was focused on using online labs (i.e. VISIR) in courses on electricity and electronics. In addition, creating a community of practice around online labs can facilitate the increase of collaborative and cooperative work among researchers in this region by working together and sharing knowledge and experiences. Additionally, the joining a VISIR federation can allow the MENA universities to have additional experiments to effectively teach in the aforementioned courses.

Overall, this dissertation introduced the “3Fs model”, which comprises three factors: i) Online Labs –*VISIR*– (see CHAPTER 4), ii) Community of Practice around Online Labs (see CHAPTER 5), iii) online labs federation –*VISIR Federation*– (see CHAPTER 6).

Therefore, the research objectives entailed the following studies:

1. A study on the existing higher education systems in the MENA region for targeting problems and limitations that exist in this region, especially in science and engineering disciplines [15].

2. A study on the existing relations among the MENA researchers, in particular in the online labs field [103].

3. A study on the scenarios of integrating instructional technologies (e.g. online labs) in higher education systems in the MENA region, and the possible methods of accessing online learning resources.

Briefly, the main outcomes of disseminations related to this dissertation are:

1. Authored several contributions to conferences and journals, plus a book chapter, addressing the PhD research focus.

2. Created a research community around online labs in the Kurdistan region, Iraq.

3. Developed and implemented a set of online experiments for the MENA region, especially in science and engineering disciplines, as follow:

- **VISIR @ IPP-ISEP**[i].

This node now supports native languages from the MENA region languages, e.g. Arabic and Kurdish. Overall, this node allows MENA institutions to use a set of experiments and share information and knowledge, specifically in electronics engineering and physics curricula.

- **REXNet project @ OSU**[ii].

This project is the result of collaborative work with the Oklahoma State University, United States. This project aims to develop an online virtual laboratory targeting computer science and engineering students. Its environment is composed of several learning modules for robotics (i.e. Revolute Arm, Gantry, Automated Gantry, Auto W/point Picking, and Factory).

8.3 PROBLEMS AND LIMITATIONS

Several problems and limitations arose during the course of this study. The most serious ones were:

- The collected data was limited to the number of papers published by the MENA researchers in conferences and journals related to online labs. As we observed in chapter 3, section 3.3.3: the researchers in the MENA region have not published many contributions about the use of instructional technologies - online labs..
- The whole MENA region had no community of practice around online labs.
- The MENA region does not have one single VISIR system installed, so it is not a contributing member of the VISIR federation, yet.

---

[i] http://193.136.60.179:8080/Home/Details?name=VISIR%2B

[ii] http://tinyurl.com/jtf96m3

- As other regions around the world, the MENA region includes several different countries. Overall, it was difficult to follow the same strategy applied to Kurdistan region universities, in Iraq, to other MENA universities, due to travelling, budget, time, etc.

8.4 RECOMMENDATIONS AND FUTURE DIRECTIONS

Educational researchers need to continue researching for ascertaining new solutions that can contribute to enhance higher education systems. In general, the MENA researchers should continue identifying the types of instructional technologies that can assist and develop their teachers and students skills.

Regarding continued development of higher education system in the MENA region, several recommendations are made in this thesis, such as:

- Installing a VISIR node[i] in the MENA region for sharing results with other researchers from the MENA region in order to enable them to address more solutions for developing their higher education systems and increasing their collaborative and cooperative work. In addition, become a part of VISIR federation.
- Integrating other inexpensive platforms for installing a VISIR node, for example VirtualBench, instead of using the PXI or LXI platforms.
- Involving more researchers from the MENA region in the area of online labs.

As the nature of research always raises other questions or future directions, the following points are also future directions of work:

- Extending VISIR experiments to secondary schools in the MENA region.
- Developing online experiments to postgraduate students for completing their research projects.

---

[i] Based on several contacts that happened between a university from Morocco and BTH, it seems this university is going to install a new VISIR node in 2017.

- Integrating REXNet project into LMS and sharing its results with other MENA researchers.
- Including other online experiments from different projects (e.g. iLab, Labshare).
- Using 3D environment technologies (e.g. Virtual Reality based on remote labs) for teaching and learning approaches.
- Finally, increasing the Community of Practice size.

8.5 CONCLUSION

In general, this thesis addressed several topics related to using instructional technologies in the MENA region, namely:

- Developing the skills of the MENA researchers and faculty staff by training and educating them, on the use of online labs.
- Supporting the higher education systems by including instructional technologies (i.e. online labs)
- Extending the internal and external dimensions of collaborative and cooperative work by sharing the work results and outcomes among MENA researchers, and also enabling the researchers to address more solutions in order to develop their higher education systems.

Heading back to the thesis chapters, briefly, chapter 1 introduced science and engineering education, problem statement, research focus, and the research objectives of this study. Chapter 2 provided a systematic literature review on online labs and their impact on education and how they can support students and teachers to perform experiments and increase collaborative and cooperative work among them. Chapter 3 described the phases of the applied research methodology and it showed the work directions. Chapter 4 described the new VISIR node at IPP-ISEP for serving the MENA universities and their students and teachers. Chapter 5 showed how the community of practice around online labs can be built, on which principles, and what are the benefits to have such a community in the MENA region. Chapter 6 illustrated the idea of the VISIR federation and showed how this federation can assist students and teachers for balancing and running the experiments among VISIR nodes. Chapter 7 described the findings and results of this work, and discussed its expected impact. Finally, this chapter provided an overview of the study, the limitations faced, drawing the results and outcomes, and recommendations and future directions.

This thesis has introduced the proposed 3Fs model for enhancing the higher education systems in the MENA region and increasing collaborative and cooperative work among their researchers. Together, it covered three complementary directions: Online Labs, Community of Practice around Online Labs, and Online Labs Federation. In general, the goals are simple but ambitious, as summarized in the following points:

- Supporting higher education systems in the MENA region, specifically in STEM education.
- Increasing collaborative and cooperative work among the MENA researchers in science and engineering areas, particularly on online labs.
- Providing didactical materials and instructional technologies for assisting teachers and students in the MENA region.

Upon reaching the end of this thesis, I remain truly convinced that, for enhancing higher education systems in the MENA countries, it is indispensable that these countries become capable of incorporating in their programmes of study and in their everyday practice didactic materials and instructional technologies that support the teachers in their lessons and help students acquire the new skills they need. Furthermore, it is highly recommended that new opportunities arise for collaborative and cooperative work among researchers in the universities in those countries, and also between themselves and the rest of the world. Online labs, which were the focus of our research, form a technology that can help steer the higher education systems in the MENA countries in the right direction, didactically and scientifically.

REFERENCES

[1] M. McAleese, *et al.*, "High Level Group on the Modernisation of Higher Education: Report to the European Commission on Improving the Quality of Teaching and Learning in Europe's Higher Education Institutions," European Commission, Luxembourg, June 2013. DOI: 10.2766/42468.

[2] UK Essays, "Positive and Negative Impacts That ICT on Education Essay," [Online available] https://www.ukessays.com/essays/education/positive-and-negative-impacts-that-ict-on-education-education-essay.php, 23 March, 2015, Retrieved on 28, December 2016.

[3] Y. Punie, D. Zinnbauer and M. Cabrera, "A Review of the Impact of ICT on Learning," Working Paper prepared for DG EAC, European Communities, Luxembourg, October 2006.

[4] S. Noor-Ul-Amin, "An Effective use of ICT for Education and Learning by Drawing on Worldwide Knowledge, Research, and Experience: ICT as a Change Agent for Education," *Scholarly Journal of Education*, Vol.2, No.4, 2013.

[5] A. B. Youssef and M. Dahmani, "The Impact of ICT on Student Performance in Higher Education: Direct Effects, Indirect Effects and Organisational Change," in *RUSC. Universities and Knowledge Society Journal*, Vol.5, No.1, 2008.

[6] A. Aristovnik, "The Impact of ICT on Educational Performance and Its Efficiency in Selected EU and OECD Countries: A Non-Parametric Analysis," in *The Turkish Online Journal of Educational Technology (TOJET)*, Vol.11, No.3, pp. 144-152, July 2012.

[7] A. Alexiou, C. Bouras and E. Giannaka, "Virtual Laboratories in Education: A Cheap Way for Schools to Obtain Laboratories for All Courses, by Using the Computer Laboratory," Technology Enhanced Learning, Chapter 2, pp. 19-28, Jean-Pierre Courtiat, Costas Davarakis and Thierry Villemur Eds, Edition 1, Spring US, Toulouse, France, 2005.

[8] J. V. Nickerson, *et al.*, "A model for evaluating the effectiveness of remote engineering laboratories and simulations in education," *In Computers and*

Education Journal, Vol.49, pp. 708-725, 2007. http://dx.doi.org/10.1016/j.compedu.2005.11.019

[9] S. Frerich and M. Petermann, "Virtual Labs and Remote Labs: Practical experience for everyone," in Global Engineering Education Conference (EDUCON), 2014 IEEE, pp. 312-314, 2014. DOI: 10.1109/EDUCON.2014.6826109

[10] J. A. Ejiwale, "Barriers to Successful Implementation of STEM Education," *In Journal of Education and Learning*, Vol.7, No.2, pp. 63-74, 2013. DOI: http://dx.doi.org/10.11591/edulearn.v7i2.220

[11] J. E. Froyd, P. C. Wankat and K. A. Smith, "Five Major Shifts in 100 Years of Engineering Education," In *Proceedings of the IEEE*, Vol.100, pp. 1344-1360, May 2012, DOI: 10.1109/JPROC.2012.2190167

[12] R. Bhandari and A. El-Amine, "Higher Education Classification in the Middle East and North Africa: A Pilot Study," [Online available] http://www.iie.org/Research-and-Publications/Publications-and-Reports/IIE-Bookstore/MENA-Institutional-Classification-Study.#.V8DUuFuLSM8, 2012, Retrieved on 1, August 2016.

[13] Al Masah Capital Management Limited, "MENA Education Report: Key Issues and Challenges," 2013.

[14] World Bank Group," Economic Returns to Investment in Education," [Online Available] http://siteresources.worldbank.org/INTMENA/Resources/EDU_02-Chap02-Education.pdf, Retrieved on 28, December 2016.

[15] R.M. Salah., G.R. Alves and P. Guerreiro, "Reshaping Higher Education Systems in the MENA Region: The Contribution of Remote and Virtual Labs," in *Remote Engineering and Virtual Instrumentation Conference (REV) Proceedings*, pp. 240-245, 2014. DOI: 10.1109/REV.2014.6784265

[16] J. Foley, "A Simple, Sure-fire Way to Create Great Content – The 5 W's & the H," [Online Available] https://premium.wpmudev.org/blog/a-simple-sure-fire-way-to-create-great-content-the-5-w-the-h/, December 8, 2011, Retrieved on 28, December 2016.

[17] E.C. Martins and F. Terblanche, "Building Organisational Culture that Stimulates Creativity and Innovation," *In European Journal of Innovation Management*, Vol.6, No.1, pp. 64-74, 2003. DOI: http://dx.doi.org/10.1108/14601060310456337.

[18] I. Gustavsson, *et al.*, "The VISIR Open Lab Platform 5.0 – An Architecture for a Federation of Remote Laboratories," in *Remote Engineering and Virtual Instrumentation Conference (REV) Proceedings*, pp. 284-288, 2011.

[19] Learning styles online, "Overview of Learning Styles," [Online available] http://www.learning-styles-online.com/overview/, Retrieved on 1, August 2016.

[20] D. Obst and J. Forster, "Perceptions of European Higher Education in Third Countries: Outcomes of a Study by the Academic Cooperation Association (ACA)," Country Report: USA, Institute of International Education, n.d.

[21] H. Al-Khatib, "Towards a Paradigm Shift in Higher Education in the MENA region," Handbook of Research on Handbook of Research on Higher Education in the Mena Region: Policy and Practice, chapter 2, pp.8-30, 2014.

[22] UNESCO, "ICT in Education," [Online available] http://www.unesco.org/new/en/unesco/themes/icts/, 2016, Retrieved on 8, September 2016.

[23] J. Anderson and T. van Weert, "Information and Communication Technology in Education: A Curriculum for Schools and Programme of Teacher Development," UNESCO Book, [Online available] http://unesdoc.unesco.org/images/0012/001295/129538e.pdf, 2002, Retrieved on 8, September 2016.

[24] K. A. Bingimlas, "Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of the Literature," *EURASIA Journal of Mathematics, Science and Technology Education*, Vol.5, No.3, pp.235-245, 2009.

[25] J. L. Moore, C. Dickson-Deane and K. Galyen, "E-Learning, Online Learning, and Distance Learning Environments: Are They The Same?," *In The Internet and Higher Education*, Vol.14, No.2, pp.129-135, 2011.

[26] J. R. Brinson, “Learning Outcome Achievement in Non-Traditional (virtual and remote) versus Traditional (Hands-On) Laboratories: A Review of The Empirical Research,” *In Computers & Education*, Vol.78, pp.218-237, 2015.

[27] M. R. Davis, “Simulated vs. Hands-On Lab Experiments: New model is likely to require more actual lab work for those taking Advanced Placement courses online,” [Online available] http://www.edweek.org/dd/articles/2009/06/17/04simulated.h02.html, 2009, Retrieved on 2, August 2016.

[28] American Chemical Society (ACS), “Importance of Hands-on Laboratory Science,” [Online available] https://www.acs.org/content/acs/en/policy/publicpolicies/invest/computersimulations.html, Retrieved on 2, August 2016.

[29] Amrita University, “Online Labs,” [Online available] http://www.olabs.edu.in/, Retrieved on 2, August 2016.

[30] M. Sasikumar, “OLabs makes school laboratories accessible anytime, anywhere,” [Online Available] http://opensourceforu.com/2016/09/olabs/, 2016, Retrieved on 30, September 2016.

[31] B. Kitchenham and S. Charters, “Guidelines for performing Systematic Literature Reviews in Software Engineering,” Version 2.3, Keele University and University of Durham, EBSE Technical Report, [Online Available] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.117.471&rep=rep1&type=pdf, 2007, Retrieved on 8, September 2016.

[32] P. Cronin, *et al.*, “Undertaking a literature review: a step-by-step approach,” *British Journal of Nursing*, Vol.17, No.1, pp.38-43, 2008.

[33] R.M. Salah, P. Guerreiro and G.R. Alves, “A Federation of Online Labs for Assisting Engineering and Science Education in the MENA Region,” *In International Conference Technological Ecosystems for Enhancing Multiculturality (TEEM) Proceedings*, pp.651-658, 2015.

[34] A. Kofod-Petersen, “How to do a Structured Literature Review in computer science,” Version 0.2, pp.1-7, 2014.

[35] Eurydice Report, “Modernisation of Higher Education in Europe: Access, Retention and Employability,” [Online available] http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/165EN.pdf, 2014, Retrieved on 2, August 2016.

[36] A. Akkari, “Education in the Middle East and North Africa: The Current Situation and Future Challenges,” *International Education Journal*, Vol.5, No.2, pp.144-153, 2004.

[37] S. Balawi, K. Khalaf and G. W. Hitt, “Leveraging Pedagogical Innovations for Science, Technology, Engineering, and Mathematics (STEM) Education in the Middle East Context,” Handbook of Advances in Engineering Education in the Middle East and North Africa: Current Status and Future Insights, chapter 4, pp.59-115, 2016.

[38] M. Samaka and M. Ally, “Model for Transferring Engineering Education Using Technology-Enhanced Learning,” Handbook of Advances in Engineering Education in the Middle East and North Africa: Current Status and Future Insights, chapter 5, pp. 117-138, 2016.

[39] World Bank, "The Road Not Traveled: New Challenges Facing the Education Sector in MENA," The World Bank, Washington, D.C., 2008.

[40] E. Khalifa and D. Obst, “Innovation through Education: Building the Knowledge Economy in the Middle East,” 2010.

[41] M. Abdulwahed, M. O. Hasna and J. E. Froyed, “Purpose of the Book and Editorial Perspectives,” Handbook of Advances in Engineering Education in the Middle East and North Africa: Current Status and Future Insights, chapter 1, pp. 3-10, 2016.

[42] World Economic Forum, “Global Education Initiative MENA Roundtable on Entrepreneurship Education,” 2010.

[43] World Bank, “Education in the Middle East and North Africa,” [Online available] http://www.worldbank.org/en/region/mena/brief/education-in-mena, 2014, Retrieved on 2, August 2016.

[44] S. AL-Masri, "Education in the Middle East," [Online available] https://www.entrepreneur.com/article/245762, 2015, Retrieved on 2, August 2016.

[45] P. Powell-Davies, "Education Reform and Improvement in MENA," [Online available] http://www.britishcouncil.org.eg/en/symposium/thought-pieces/education-reform-and-improvement-mena, 2015, Retrieved on 2, August 2016.

[46] World Innovation Summit for Education (WISE), "Education Survey: Connecting Education to the Real World," 2015.

[47] T. Anderson and F. Elloumi, "Theory and Practice of Online Learning," 2004.

[48] M.O. Yusuf, "Information and communication education: Analyzing the Nigerian national policy for information technology," *International Education Journal*, Vol.6, No.3, pp. 316-321, 2005.

[49] B. Moeller and T. Reitzes, "Integrating Technology with Student-Centered Learning," A Report to the Nellie Mae Education Foundation, The Nellie Mae Education Foundation, 2011.

[50] B. C. Nix, *et al.*, "Integrating Technology with Teaching and Learning at Murray State University," *Contemporary Issues in Technology and Teacher Education Journal*, Vol.4, No.1, pp.55-63, 2004.

[51] E. de Graaff, "Developments in Engineering Education and Engineering Education Research in Europe," Handbook of Advances in Engineering Education in the Middle East and North Africa: Current Status and Future Insights, chapter 2, pp. 11-33, 2016.

[52] D. Liua, *et al.*, "Integration of Virtual Labs into Science E-learning," *Procedia Computer Science Journal*, Vol.75, pp.95-102, 2015.

[53] C. Wang, "A Review of Research on Technology-Assisted School Science Laboratories," *Educational Technology and Society Journal*, Vol.17, No.2, pp.307–320, 2014.

[54] M. Ožvoldová and P. Ondrůšek, "Integration of Online Labs into Educational Systems," *International Journal of Online Engineering (iJOE)*, Vol.11, No.6, pp.54–59, 2015.

[55] B. Means, *et al.*, "Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies," Washington, DC: U.S. Department of Education, 2010.

[56] M. Bakia, *et al.*, "Understanding the Implications of Online Learning for Educational Productivity," Washington, DC: U.S. Department of Education, 2012.

[57] M. Bakia, et al. "Implementing Online Learning Labs in Schools and Districts: Lessons From Miami-Dade's First Year," Menlo Park, CA: SRI International, 2011.

[58] E. Allen and J. Seaman, "Changing Course: Ten Years of Tracking Online Education in the United States," Babson Survey Research Group Report, [Online available] http://sloanconsortium.org/publications/survey/changing_course_2012, 2013, Retrieved on 2, August 2016.

[59] D. Xu and S. S. Jaggars, "Adaptability to Online Learning: Differences across Types of Students and Academic Subject Areas," CCRC Working Paper No. 54, 2013.

[60] D. Vioreanu, "Quality Aspects of Open, Distance and Online Learning," [Online available] http://www.distancelearningportal.com/articles/924/quality-aspects-of-open-distance-and-online-learning.html, 2016, Retrieved on 2, August 2016.

[61] K-12 Blueprint, "Learning Management System (LMS) Guide," Sponsored by Intel Education, 2014.

[62] M. A. Bochicchio and A. Longo, "Extending LMS with Collaborative Remote Lab features," *In 10th IEEE International Conference on Advanced Learning Technologies*, pp.310-314, 2010.

[63] N. Adzharuddin and L. H. Ling, "Learning Management System (LMS) among University Students: Does It Work?," *International Journal of e-Education, e-Business, e-Management and e-Learning*, Vol.3, No.3, pp.248-252, 2013.

[64] Epignosis LLC, “E-Learning Concepts, Trends, Applications,” San Francisco, California: USA, Version 1.1, January 2014.

[65] A. Esposito, “Research ethics in emerging forms of online learning: issues arising from a hypothetical study on a MOOC,” *Electronic Journal of e-Learning*, Vol.10, No.3, pp.315-325, 2012.

[66] T. Nguyen, “The Effectiveness of Online Learning: Beyond No Significant Difference and Future Horizons,” *MERLOT Journal of Online Learning and Teaching*, Vol.11, No.2, pp.309-319, 2015.

[67] MOOC List, “Free Online Courses for everyone: List of MOOCs offered by the Best Universities and Entities,” [Online available] https://www.mooc-list.com/, Retrieved on 4, August 2016.

[68] Teach.com, “Teaching Methods,” [Online available] https://teach.com/what/teachers-teach/teaching-methods/, Retrieved on 4, August 2016.

[69] D. Popescu and B. Odbert, “The Advantages Of Remote Labs In Engineering Education,” Educator’s Corner -Agilent Tech. - application note, pp.11, 2011.

[70] I. Gustavsson, *et al.*, “The VISIR project – an Open Source Software Initiative for Distributed Online Laboratories,” In *Remote Engineering and Virtual Instrumentation Conference (REV2007) Proceedings*, pp.1-6, 2007.

[71] I. Gustavsson, *et al.*, “The VISIR Open Lab Platform 5.0 - an architecture for a federation of remote laboratories,” In *Proceedings of the Remote Engineering and Virtual Instrumentation (REV)*, pp.284-286, 2011.

[72] R. Heradio, *et al.*, “Virtual and remote labs in education: A bibliometric analysis,” *Computers & Education Journal*, Vol.98, pp.14-38, 2016.

[73] D. G. Zutin and M. E. Auer, " Work in Progress - Integrating Educational Online Lab Platforms around the iLab Shared Architecture," In *Frontiers in Education Conference (FIE) Proceedings*, pp.F1G-1-F1G-3, 2011.

[74] Z. Nedic, J. Machotka and A. Nafalski, "Remote Laboratories Versus Virtual and Real Laboratories," In *33rd ASEE/IEEE Frontiers in Education Conference*, pp.1-6, 2003.

[75] D. G. Zutin, *et al.*, "Lab2go - A Repository to Locate Educational Online Laboratories," In *Global Education Engineering conference (EDUCON)*, 2010 IEEE, Madrid, Spain, pp.1741-1746, 2010.

[76] Y. Li, S. K. Esche and C. Chassapis, "A Scheduling System for Shared Online Laboratory Resources," In *38th ASEE/IEEE Frontiers in Education Conference*, pp.1-6, 2008.

[77] J. Ma and J. V. Nickerson, "Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review," *ACM Computing Surveys*, Vol.38, No.3, pp.1-24, 2006.

[78] H. M. Babateen, "The role of Virtual Laboratories in Science Education," In 5th International Conference on Distance Learning and Education, pp.100-104, 2011.

[79] P. A. Hatherly, "The Virtual Laboratory and Interactive Screen Experiments," [Online available] https://web.phys.ksu.edu/icpe/publications/teach2/Hatherly.pdf, Retrieved on 4, August 2016.

[80] S. Mehta, M. Bajaj and H. Banati, "An Intelligent Approach for Virtual Chemistry Laboratory," Handbook of Research on Advanced Hybrid Intelligent Techniques and Applications, chapter 16, pp.483-517, 2016.

[81] Remote-labs.eu., "Virtual Labs," [Online available] http://online-labs.eu/virtual-labs/, 2013, Retrieved on 4, August 2016.

[82] M. Casini, D. Prattichizzo and A. Vicino, "E-Learning by Remote Laboratories: A New Tool for Control Education," in Proc. Preprints 6th IFAC Symp. Advances Control Edu., pp.95–100, 2003.

[83] L. Gomes and J. García-Zubía, "Advances on remote laboratories and e-learning experiences," Book Edition, University of Deusto, Bilbao, 2007.

[84] J. García-Zubía and G. R. Alves, "Using Remote Labs in Education: Two Little Ducks in Remote Experimentation," Book Edition, University of Deusto, Bilbao, 2011.

[85] Remote-labs.eu., "Remote Labs," [Online available] http://online-labs.eu/remote-labs/, 2013, Retrieved on 4, August 2016.

[86] A. Hill, "What Is Collaboration in the Workplace? - Definition, Benefits & Examples," [Online available] http://study.com/academy/lesson/what-is-collaboration-in-the-workplace-definition-benefits-examples.html, Retrieved on 4, August 2016.

[87] A. Nafalski, *et al*., "Collaborative Learning in Engineering Remote Laboratories," In *Remote Engineering and Virtual Instrumentation Conference (REV) Proceedings*, pp.242-245, 2009.

[88] D. Lowe, et al., "Adapting a Remote Laboratory Architecture to Support Collaboration and Supervision," *International Journal of Online Engineering (iJOE)*. Vol.5, pp.51-56, 2009.

[89] D. Müller and H.H. Erbe, "Collaborative Remote Laboratories in Engineering Education: Challenges and Visions," Advances on remote laboratories and e-learning experiences," Book Edition, Chapter 2, University of Deusto, Bilbao, 2007.

[90] G. J. Fakas, A. V. Nguyen and D. Gillet," The Electronic Laboratory Journal: A Collaborative and Cooperative Learning Environment for web-Based Experimentation," *Computer Supported Cooperative Work*, Vol.14, pp.189-216, 2005.

[91] J. Machotka, Z. Nedic and Ö. Göl, "Collaborative Learning in the Remote Laboratory NetLab," *Systemics, Cybernetics and Informatics*, Vol.6, No.3, pp.22-27, 2010.

[92] J. Machotka and Z. Nedic, "The Remote Laboratory NetLab for Teaching Engineering Courses," *Global Journal of Engineering Education*, Vol.10, pp.202-212, 2006.

[93] I. Gustavsson, *et al.*, "On Objectives of Instructional Laboratories, Individual Assessment, and Use of Collaborative Remote Laboratories," *IEEE Transactions on Learning Technologies*, Vol.2, No.4, pp.263–274, 2009.

[94] R.J. Lilford, *et al.* "Issues in methodological research: perspectives from researchers and commissioners" *Health Technology Assessment*, Vol.5, No.8, pp.1-68, 2001.

[95] SkillsYouNeed.com, "Writing your Dissertation: Methodology" [Online available] http://www.skillsyouneed.com/learn/dissertation-methodology.html, Retrieved on 15, October, 2016.

[96] Dissertation Help Service, "Help with Your Dissertation: A Place where you learn how to complete Your Dissertation," [Online available] http://www.howtodo.dissertationhelpservice.com/what-is-research-methodology-and-its-importance/, Retrieved on 15, October, 2016.

[97] S. Rajasekar, P. Philominathan and V. Chinnathambi, "Research Methodology," [Online available], https://arxiv.org/pdf/physics/0601009.pdf, 2013, Retrieved on 15, October, 2016.

[98] C.R. Kothari, "Research Methodology: Methods and Techniques," 2nd Revised Edition, Published by New Age International, New Delhi, India, 2004.

[99] The Write Pass Journal, "How to Write a Dissertation: Methodology," [Online available] https://writepass.com/journal/2012/06/how-to-write-a-dissertation-methodology/, 2013, Retrieved on 15, October, 2016.

[100] R. Kumar, "Research Methodology: a step-by-step guide for beginners," 2nd Edition, Published by SAGE Publications Ltd, New Delhi, India, 2005.

[101] C. A. Paulsen and D. Dailey, "A Guide for Education Personnel: Evaluating a Program or Intervention," [Online available] http://www.air.org/resource/guide-education-personnel-evaluating-program-or-intervention, 2002, American Institutes for Research, Retrieved on 19, October, 2016.

[102] R. R. Powell, "Evaluation Research: An Overview," *Library Trends*, Vol.55, No.1, pp.102-120, 2006.

[103] R.M. Salah., G.R. Alves and P. Guerreiro, “IT-Based Education with Online Labs in the MENA Region: Profiling the Research Community” *International Journal of Human Capital and Information Technology Professionals (IJHCITP)*, Vol. 6, No. 4, pp. 1–26, 2015.

[104] E. Sancristobal, *et al.*, "Remote labs as learning services in the educational arena," In *Global Engineering Education Conference (EDUCON) Proceedings*, pp. 1189-1194, 2011.

[105] R.M. Salah, *et al*., “Why VISIR? Proliferative activities and collaborative work of VISIR system”, In *7th annual International Conference on Education and New Learning Technologies (EDULEARN15) Proceedings*, pp. 3824-3835, 2015.

[106] M. Tawfik, *et al*., “VISIR: Experiences and Challenges”, *International Journal of Online Engineering (iJOE)*, Vol. 8, pp. 25-32, Feb. 2012.

[107] I. Gustavsson, *et al.,* “The VISIR Project: An Open Source Software Initiative for Distributed Online Laboratories,” In *Remote Engineering and Virtual Instrumentation Conference (REV) Proceedings*, 2007.

[108] R.M. Salah, *et al*., “Using UML Models to Describe the VISIR System,” *International Journal of Online Engineering (iJOE)*, Vol. 12, No. 6, pp. 34-42, 2016.

[109] I. Gustavsson, “Administrator’s Guide to the VISIR Online Laboratory for Electrical Experiments” 2013.

[110] I. Gustavsson, “Teacher’s Guide to the VISIR Online Laboratory for Electrical Experiments on a Breadboard,” [Online available] http://openlabs.bth.se/static/Teacher_manual_10.pdf, Retrieved on 22, March, 2016.

[111] I. Gustavsson, “Student’s Guide to the VISIR Remote Laboratory for Electrical Experiments,” [Online available] http://openlabs.bth.se/static/VISIR_Student_manual_16.pdf, Retrieved on 22, March, 2016.

[112] L. C. M. Schlichting, *et al.*, "Remote Laboratory: application and usability", In *Technologies Applied to Electronics Teaching Conference (TAEE) Proceedings*, pp. 1-7, 2016.

[113] I. Gustavsson, *et al.*, "Lab sessions in VISIR laboratories", In *Remote Engineering and Virtual Instrumentation Conference (REV) Proceedings*, pp. 350-352, 2016.

[114] G. R. Alves, *et al.*, "Using VISIR in a large undergraduate course: Preliminary assessment results," In *Global Engineering Education Conference (EDUCON) Proceedings*, pp. 1125-1132, 2011.

[115] Blekinge Institute of Technology (BTH), "Conference on laboratory work over the Internet," [Online available] http://www2.bth.se/eng/newsarticles.nsf/pages/ce120f9dd73b00a1c1257f4d003c0155?OpenDocument, 2016, Retrieved on 8, Jun, 2016.

[116] R.M. Salah, *et al.*, "VISIR system @ BTH, DEUSTO, ISEP, AND UNED institutes: Assisting and supporting hands-on laboratories to serve higher education students," In *8th annual International Conference of Education, Research and Innovation (ICERI) Proceedings*, pp. 2535-2547, 2015.

[117] J. Garcia-Zubia, *et al.*, "WebLab-Deusto-CPLD: A practical experience" *International Journal of Online Engineering (iJOE)*, Vol 8, special issue exp.at'11 pp. 17-18, 2011.

[118] J. Garcia-Zubia, *et al.*, "Integración del laboratorio remoto WebLab-Deusto en Moodle," In *MoodleMoot Euskadi Proceedings*, May 2009. In Spanish

[119] P. Zervas, "The Go-Lab Inventory and Integration of Online Labs - Labs Offered by Large Scientific Organisations," 2014.

[120] L. Rodriguez-Gil, *et al.*, "Advanced integration of OpenLabs VISIR (Virtual Instrument Systems in Reality) with Weblab-Deusto," In *Remote Engineering and Virtual Instrumentation Conference (REV) Proceedings*, pp. 1-7, 2012.

[121] D. G. Zutin, M. E. Auer and I. Gustavsson, "A VISIR lab server for the iLab Shared Architecture," In *Global Engineering Education Conference (EDUCON) Proceedings*, IEEE, pp. 30-33, 2011.

[122] U. H. Jayo, "Metodología de Control Independiente de Instrumentos y Experimentos para su Despliegue en Laboratorios Remotos," Doctoral Thesis, Facultad de Ingenieria, Universidad de Deusto, 2012. (In Spanish)

[123] M. S. T. Abuelela, "Laboratory as a Service (LaaS): a Paradigm for Developing and Implementing Modular Remote Laboratories," Doctoral Thesis, Departamento de Ingeniería Eléctrica, Electrónica, y de Control, Universidad Nacional de Educación a Distancia, 2013.

[124] J. Garcia-Zubia and U. H. Jayo, "LXI technologies for remote labs: An extension of the VISIR project," International Journal of Online Engineering (iJOE), Vol. 6, No. 1, pp. 25–35, 2010.

[125] C. Ramos, "Projects EU-Brazil using existing opportunities", [Online available] http://www.b-bice-plus.eu/wp-content/uploads/Carlos-Ramos-IPP.pdf, Retrieved on 12, March, 2016.

[126] Empressoemprego.pt, "Português lidera expansão de laboratório remoto de topo", [Online available] http://expressoemprego.pt/noticias/portugues-lidera expansao-de-laboratorio-remoto-de-topo/3949, Retrieved on 12, March, 2016. (In Portuguese).

[127] Great Schools Partnership, "The Glossary of Education Reform," [Online available] http://edglossary.org/education-system/, Retrieved on 12, April 2016.

[128] Direção-Geral do Ensino Superior, "Portuguese Higher Education: Portuguese Educational System," [Online available] http://www.studyinportugal.edu.pt/index.php/study/portuguese-higher-education, Retrieved on 12, April 2016.

[129] Alfa PUENTES project, "Innovative Strategies for Higher Education in Latin America and Europe: International Collaboration and Regional Development," Sao Paulo, Brazil, 11 - 14, November 2012.

[130] P.M. Callan, *et al.*, "Good Policy, Good Practice, Improving Outcomes and Productivity in Higher Education: A Guide for Policymakers," 2007.

[131] R.M. Salah, "Remote Labs to improve Engineering Education in the MENA Region," In *International Conference on Engineering Education and Research (ICEER) Proceedings*, pp. 1-8, 2013.

[132] H.A. El-Ghali, Q. Chen and J.L. Yeager, "Innovation through Education: Building the Knowledge Economy in the Middle East," 2010.

[133] N. Baporikar, "Handbook of Research on Higher Education in the MENA Region: Policy and Practice," Publisher: IGI Global, United States, 2014.

[134] J. DeBoer, "Perspectives on Engineering Education Quality in Tunisia After 50 Years of Statehood," Handbook of Advances in Engineering Education in the Middle East and North Africa: Current Status and Future Insights, chapter 16, pp. 377-408, Springer International Publishing, Edition One, 2016, Switzerland, DOI 10.1007/978-3-319-15323-0_16.

[135] M. T. Restivo and G. R. Alves, "Acquisition of higher-order experimental skills through remote and virtual laboratories", in IT Innovative Practices in Secondary Schools: Remote Experiments, 1st ed. Bilbao, Spain: University of Deusto, Chapter, pp. 321-247, 2013.

[136] L. Feisel, A. Rosa, "The role of the laboratory in undergraduate engineering education", *Journal of Engineering Education*, Vol. 94, No. 1, pp. 121-130, 2005.

[137] J. Skalicky and M. West, "UTAS Community of Practice Initiative: Readings and Resources," 2006.

[138] A. Couros, "Communities of Practice: A Literature Review," [Online available] https://www.tcd.ie/CAPSL/_academic_practice/pdfdocs/Couros_2003.pdf, 2003, Retrieved on 18, April 2016.

[139] E. Wenger, "Communities of practice: a brief introduction," [Online available] http://wenger-trayner.com/wp-content/uploads/2015/04/07-Brief-introduction-to-communities-of-practice.pdf, 2015, Retrieved on 18, April 2016.

[140] C. Hoadley, “What is a Community of Practice and How Can We Support It?,” In: D. Jonassen & S. Lund (Eds.), Theoretical foundations of learning environments (2nd ed., pp. 286–300). New York, NY: Routledge, 2012.

[141] A. M. Cox, “What are communities of practice? A comparative review of four seminal works,” *Journal of Information Science*, Vol. 31, No. 6, pp. 527-540, 2015.

[142] E. Wenger, “Communities of practice and social learning systems: the career of a concept”, In: E.C. Wenger (Ed.) Social learning Systems and communities of practice, p.179, Dordrecht: Springer, 2001.

[143] O. Serrat, “Building Communities of Practice,” [Online available] http://www.adb.org/sites/default/files/publication/27564/building-communities-practice.pdf, Retrieved on 18, April 2016.

[144] E. Wenger, “Communities of practice: Learning, meaning, and identity,” Cambridge University Press: Cambridge, UK, 1998.

[145] E. Wenger, “Supporting communities of practice: a survey of community-oriented technologies,” [Online available] https://guard.canberra.edu.au/opus/copyright_register/repository/53/153/01_03_CP_technology_survey_v3.pdf, 2001, Retrieved on 18, April 2016.

[146] A. Bourhis, L. Dubé and R. Jacob, ”The Success of Virtual Communities of Practice: The Leadership Factor,” *Electronic Journal of Knowledge Management*, Vol. 3, No. 1, pp. 23-34, 2005.

[147] L. Dube, A. Bourhis and R. Jacob, ”Towards a Typology of Virtual Communities of Practice,” *Interdisciplinary Journal of Information, Knowledge, and Management*, Vol. 1, No. 1, pp. 69-93, 2006.

[148] K. Stanoevska-Slabeva, “Toward a Community-Oriented Design of Internet Platforms,” *International Journal of Electronic Commerce*, Vol. 6, No. 3, pp. 71–95, 2002.

[149] J. Lazar and J. Preece, “Classification Schema for Online Communities,” in *the 1998 Association for Information Systems, Americas Conference Proceedings*, pp. 84-86, 1998.

[150] S. Jones, “Understanding Community in the Information Age” in CyberSociety: Computer-Mediated Communication and Community,” S. Jones (ed.), Sage Publications, Thousand Oaks, California, pp. 10-33, 1995.

[151] California State University, “Teaching Methods and Techniques,” [Online available] https://www.csusm.edu/ids/course-design-and-instruction/teaching-%20methods-and-techniques/index.html, Retrieved on 20, April 2016.

[152] G.R. Alves, *et al*., “Large and small scale networks of remote labs: a survey,” Eds: Advances on remote laboratories and e-learning experiences, pp. 15-34. University of Deusto, 2007.

[153] Free Management eBooks, “Performance Appraisal Rating Scales,” [Online available] http://www.free-management-ebooks.com/faqap/evaluating-05.htm, Retrieved on 22, April 2016.

[154] Peopletopia Ltd., “Performance Management ratings scales,” [Online available] http://peopletopia.co.uk/wp-content/uploads/2012/03/Guide-to-Performance-Management-rating-scales.pdf, Retrieved on 22, April 2016.

[155] E. Taylor-Powell, “Wording for rating scales,” [Online available] http://www.uwex.edu/ces/4h/evaluation/documents/Wordingforratingscales.pdf, Retrieved on 22, April 2016.

[156] L.M. Lozano, E. Garcia-Cueto and J. Muniz, “Effect of the number of response categories on the reliability and validity of rating scales,” In *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences*, Vol 4, No. 2, pp. 73-79, 2008.

[157] TVTROPES, “Four Point Scale,” [Online available] http://tvtropes.org/pmwiki/pmwiki.php/Main/FourPointScale, Retrieved on 22, April 2016.

[158] Cisco, “How Technology can Transform Higher Education in the US,” http://www.cisco.com/c/dam/en_us/solutions/industries/docs/education/technology_he_wp.pdf, [Online available], White Paper, 2013, Retrieved on 23, April 2016.

[159] Botswana Federation of Trade Unions (BFTU), “Policy on Education in BOTSWANA,” March, 2013, [Online available] http://library.fes.de/pdf-files/bueros/botswana/04922.pdf Retrieved on 3, June 2016.

[160] United Nations Educational, “Engineering: Issues Challenges and Opportunities for Development,” Scientific and Cultural Organization (UNESCO) Report, 2010.

[161] H. Grinager, “How Education Technology Leads to Improved Student Achievement”, In *National Conference of State Legislatures*, pp. 1-12, 2006,.

[162] National Education Association, “Access, Adequacy, and Equity in Education Technology: Results of a Survey of America’s Teachers and Support Professionals on Technology in Public Schools and Classrooms”, May 2008.

[163] D. Van Roekel, “Technology in schools: The ongoing challenge of access, adequacy and equity”, National Education Association, 2008, [Online available] http://www-infocris.isea.org/assets/docs/PB19_Technology08.pdf Retrieved on 6, June 2016.

[164] P. Orduña, “Transitive and Scalable Federation Model for Remote Laboratories”, Universidad De Deusto, Bilbao, Spain, Thesis doctoral, 2013.

[165] WhatIs.com, “federated cloud (cloud federation)”, [Online available] http://whatis.techtarget.com/definition/federated-cloud-cloud-federation, Retrieved on 7, June 2016.

[166] Reference An IAC Publishing Labs Company, “What does "federation" mean?”, [Online available] https://www.reference.com/government-politics/federation-mean-77a261bd52b1150#, Retrieved on 7, June 2016.

[167] E. Killeen, "Top 5 Federated Single Sign-on (SSO) Scenarios", posted on May 2012, [Online available], http://blog.empowerid.com/blog-1/bid/153386/Top-5-Federated-Single-Sign-on-SSO-Scenarios, Retrieved on 7, June 2016.

[168] BMC Software, "What is Federation?", [Online available] http://www.bmc.com/videos/user-submitted/what-is-federation.html, Retrieved on 7, June 2016.

[169] BMC Software, "Federation and a CMDB", 2005, [Online available] http://www.ts.avnet.com/clientsolutions/federation_and_a_cmdb, Retrieved on 9, June 2016.

[170] Oracle Corporation, "Sun OpenSSO Enterprise 8.0 Technical Overview: Part III Federation Management Using OpenSSO Enterprise", [Online available] https://docs.oracle.com/cd/E19575-01/820-3740/ggqxi/index.html, Retrieved on 9, June 2016.

[171] Federation Training, "About Federation Training", [Online available] http://www.federationtraining.edu.au/about_us/about_federation_training, Retrieved on 9, June 2016.

[172] A. A. Rizzo and G. J. Kim, "A SWOT analysis of the field of virtual reality rehabilitation and therapy," *Presence: Teleoperators and Virtual Environments*, Vol. 14, No. 2, pp. 119-146, 2005.

[173] A. Davidson, *et al.*, "A SWOT Analysis of Virtual Laboratories for Security Education" In 9th IFIP World Conference on Computers in Education, pp. 1-8, 2009.

[174] T. de Jong, S. Sotiriou and D. Gillet, "Innovations in STEM education: the Go-Lab federation of online labs", *Smart Learning Environments*, Vol. 1, No. 1, pp. 1-16, 2014.

[175] D. Dikke, *et al.*, "GoLabz: Towards a Federation of Online Labs for Inquiry-Based Science Education at School" In *International Conference on Education and Learning (EDULEARN) Proceedings*, pp. 3238-3248, 2014.

[176] European Schoolnet, "Go-Lab: Global Online Science Labs for Inquiry Learning at School", April 2013, [Online available] http://www.eun.org/about/projects, Retrieved on 14, June 2016.

[177] H. Yeung, D. Lowe and S. Murray, "Interoperability of Remote Laboratories Systems," *International Journal of Online Engineering (iJOE)*, Vol. 6, No. 1, 2010.

[178] P. Orduña and J. García-Zubia, "Scheduling schemes among Internet Laboratories ecosystems," in *Remote Engineering and Virtual Instrumentation Conference (REV) Proceedings*, pp. 1-6, 2011.

[179] V. J. Harward, *et al.*, "The iLab Shared Architecture: A Web Services Infrastructure to Build Communities of Internet Accessible Laboratories," *Proceedings of the IEEE,* Vol. 96, pp. 931-950, 2008.

[180] J.L. Hardison, *et al.*, "Deploying Interactive Remote Labs Using the iLab Shared Architecture," In *IEEE/ASEE Frontiers in Education Conference (FIE) Proceedings*, pp. S2A-1-S2A-6, 2008.

[181] M. E. Auer and D. G. Zutin, "A Grid of Online Laboratories Based on the iLab Shared Architecture," In *IEEE Frontiers in Education Conference (FIE) Conference*, pp. S2H-1-S2H-2, 2012.

[182] ISEP-IPP, "VISIR+ PROJECT", [Online available] http://www2.isep.ipp.pt/visir/, Retrieved on 18, June 2016.

[183] G. R. Alves, *et al.*, "Spreading remote lab usage: A System – A Community – A Federation," In *2016 2nd International Conference of the Portuguese Society for Engineering Education (CISPEE)*, pp. 1-7, 2016.

[184] eXtension.org, "What is the difference between short-term, intermediate, and long-term outcomes?", May 2013, [Online available] http://articles.extension.org/pages/44517/what-is-the-difference-between-short-term-intermediate-and-long-term-outcomes, Retrieved on 18, June 2016.

[185] A. Toffler, "Writing SMART, Short-term Outcome Objectives", [Online available] http://www.azed.gov/century-learning-centers/files/2011/06/16.-writing-smart-short-term-outcome-objectives.pdf, Retrieved on 18, June 2016.

[186] G. Beckett, "Importance of Learning Science in School," [Online available] http://www.howtolearn.com/2013/04/importance-learning-science-school/, 2013, Retrieved on 7, September 2016.

[187] M. Abdulwahed, M. O. Hasna and J. E. Froyd, "Advances in Engineering Education in the Middle East and North Africa: Current Status, and Future Insights," Springer International Publishing, Edition One, Switzerland, 2016, DOI 10.1007/978-3-319-15323-0.

[188] R. Pastor, *et al.*, "Online laboratories as a cloud service developed by students," In *2013 IEEE Frontiers in Education Conference (FIE)*, pp. 1081-1086, 2013.

[189] R. Pastor, *et al.*, "Laboratories as a Service (LaaS): Using Cloud Technologies in the Field of Education," Journal of Universal Computer Science (JUCS), Vol.19, No.14, pp. 21121–2126, 2013.

[190] D. Sánchez, *et al.*, "On the use of cloud technologies to provide remote laboratories as a service," In *1st International Workshop on Cloud Education Environments (WCLOUD 2012)*, pp. 57-60, 2013.

[191] SEPIE, "Listado de solicitudes seleccionadas," [Online available] http://sepie.es/doc/convocatoria/2016/resoluciones/julio/ka2/KA203_AnexoIV-1-Seleccionadas.pdf, 2016, Retrieved on 7, September 2016. (In Spanish)

APPENDIX 1: PUBLICATIONS

Title: Remote Labs to improve Engineering Education in the MENA Region

Authors: Razwan Mohmed Salah

Conference: International Conference on Engineering Education and Research (iCEER)

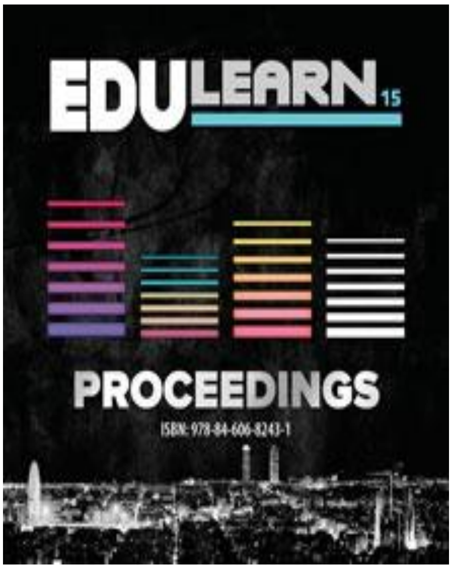
Publication date: 2013

Title: Reshaping Higher Education Systems in the MENA Region: The Contribution of Remote and Virtual Labs

Authors: Razwan Mohmed Salah, Gustavo R. Alves, Pedro Guerreiro

Conference: International Conference on Remote Engineering and Virtual Instrumentation (REV)

Publication date: 2014



Title: Why VISIR? Proliferative Activities and Collaborative Work of VISIR System

Authors: Razwan Mohmed Salah, Gustavo R. Alves, Dezheen Hussein Abdulazeez, Pedro Guerreiro, Ingvar Gustavsson

Conference: International Conference on Education and New Learning Technologies (EDULEARN15)

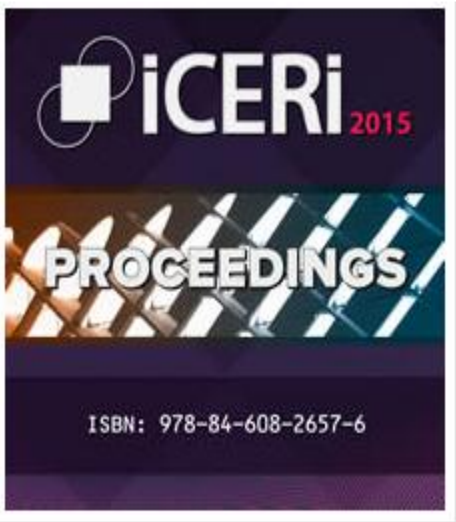
Publication date: 2015

Title: IT-Based Education with Online Labs in the MENA Region: Profiling the Research Community

Authors: Razwan Mohmed Salah, Gustavo R. Alves, Pedro Guerreiro

Journal: International Journal of Human Capital and Information Technology Professionals (IJHCITP)

Publication date: 2015



Title: VISIR System @ BTH, DEUSTO, ISEP, AND UNED Institutes: Assisting and Supporting Hands-on Laboratories to Serve Higher Education Students

Authors: Razwan Mohmed Salah, Gustavo R. Alves, Beata Datkiewicz, Pedro Guerreiro, Ingvar Gustavsson

Conference: International Conference of Education, Research and Innovation (iCERi)

Publication date: 2015

Title: A Federation of Online Labs for Assisting Engineering and Science Education in the MENA Region

Authors: Razwan Mohmed Salah, Pedro Guerreiro, Gustavo R. Alves

Conference: Technological Ecosystems for Enhancing Multiculturality (TEEM'15)

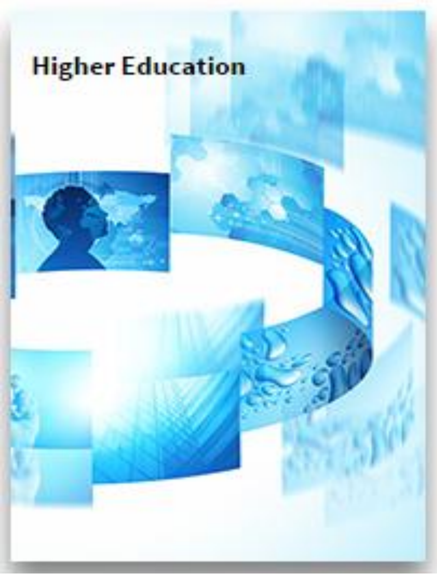
Publication date: 2015

Title: Using UML Models to Describe the VISIR System

Authors: Razwan Mohmed Salah, Gustavo R. Alves, Pedro Guerreiro, Ingvar Gustavsson

Conference: International Journal of Online Engineering (iJOE)

Publication date: 2016



Title: A Community of Practice around Online Labs in Iraq: Towards Effective Support for Academics and Higher Educational Systems in the MENA Region

Authors: Razwan Mohmed Salah, Gustavo R. Alves, Shamil Kaddoury Talal, Clara Viegas, Pedro Guerreiro

Book: Higher Education

Publication date: 2017

Title: Cyber Learning Environments for Engineering Education

Authors: Joe Cecil, Harley Richardson, Razwan Mohmed Salah

Conference: Frontiers in Education (FIE)

Publication date: Accepted (Abstract)

APPENDIX 2: QUESTIONNAIRE FORM

Thank you for kindly participating in this questionnaire. We want to continually improve, so the opinions you have provided are greatly appreciated and important.

- **Demographic Background (Please kindly tick (√) your answers to the given statements)**.

Occupation

[ ] Student

[ ] Staff

GENDER.

[ ] Male

[ ] Female

Mother language.

[ ] Kurdish

[ ] Arabic

AGE group

[ ] 18-22 Years old

[ ] 23-30 Years old

[ ] Above 30 Years old

Program taken at home university.

[ ] Physics

[ ] Electronic & computer Engineering

[ ] Computer sciences

Year of study (Just for student)

[ ] First Year

[ ] Second Year

[ ] Third Year

[ ] Final Year

Internet Use experience

[ ] Less than 1 year

[ ] 1 – 2 years

[ ] 2 – 3 years

[ ] More than 3 years

Internet Use Frequency

[ ] Everyday

[ ] 4– 6 times a week

[ ] 1-3 times a week

[ ] Less than once a week

- **Please check the appropriate column, according to your level of agreement with each sentence/question**

	Questions	Strong Agree	Agree	Disagree	Strong Disagree
1	Do you feel online labs as hands-on labs?	☐	☐	☐	☐
2	Does online labs usage improve the quality of your studies?	☐	☐	☐	☐
3	Does an online lab provide higher level of engagement in education scope?	☐	☐	☐	☐

4	Do you agree that online labs can increase the collaboration and cooperation work among students and teachers?	☐	☐	☐	☐
5	Do you think that experiments through online labs can give scope for more innovative and creative research work?	☐	☐	☐	☐
6	Do you find using online labs to be advantageous in university, for teachers and students?	☐	☐	☐	☐
7	Do you think online labs can help sharing resources?	☐	☐	☐	☐
8	Should online labs technology be used in the next years?	☐	☐	☐	☐
9	Do you think online labs can be enjoyable?	☐	☐	☐	☐
10	Does an online lab make it easier to learn and complete tasks?	☐	☐	☐	☐
11	Do you agree that new languages of online labs interfaces, such as Kurdish and Arabic, can help students to better understand how to use it?	☐	☐	☐	☐
12	Do you think that online labs use will help you to understand and support the educational curriculum?	☐	☐	☐	☐
13	Do you believe online labs (Remote Labs) actually work with real devices through the internet?	☐	☐	☐	☐
14	Do you believe online labs will eventually replace Hands-on labs?	☐	☐	☐	☐
15	Overall, do you think that online labs can be useful to create a community of practice?	☐	☐	☐	☐