Cyber Learning Environments for Sciences and Engineering Education: Remote Experimentation Labs for Kurdistan Universities

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Abstract— Currently, higher education systems in the Middle East and North Africa face several challenges in terms of developing, learning, and teaching. For example, the higher education system in Iraq, which is the same as in other countries as a whole, has not adapted instructional technology into the education system efficiently. Today, several technologies have been implemented (e.g. Remote Experimentation Labs and Virtual Reality) to serve the education systems and their teaching abilities. This paper presents a Remote Experimentation Labs project, named “Building a Remote Experimentation Network for serving higher education teachers and students in Iraq”, that is implemented to serve students and teachers of Iraqi universities. It is a collaborative and cooperative work among three universities (i.e. Duhok University, Zakho University, Duhok Polytechnic University) in Kurdistan Region-Iraq and Oklahoma State University (OSU) in United States. This project is supported by the International Research & Exchanges Board organization for creating Cyber Learning Environment with the main goal of enhancing a student's learning experience. This is accomplished by including several modules and increasing the collaborative and cooperative works among researchers in Kurdistan region, and Iraq in general.

Keywords—Remote Experimentation Labs, REXNet project, Modules, Cyber Learning Environments, Collaborative and Cooperative works.

I. INTRODUCTION

Briefly, there are two administrations of the higher Education System in Iraq: Baghdad and Erbil. The structures of these two systems are generally similar [1, 2].

In the last two decades several public and private institutions have been established in the Kurdistan region, which are operated by the Ministry of Higher Education Forms Board of Scientific Research in Kurdistan Regional Government (KRG). Starting in 1991 the KRG established its own formal mechanisms for quality assurance and recognition of higher education institutions around the world [3]. Even through reforms and the relative stability of the higher education systems in the last years, they have remained insufficient for their institutions. The reason may be that these institutions in the Kurdistan region have not been provided with enough materials, tools, and technologies that would be used for teaching their students.

In general, teaching practice provides information of educational theories to students and refers to the general principles, pedagogy, and management strategies that are included in educational practices.

Nowadays, technology plays an increasingly important role in the development of education, especially in higher
education, and has enhanced learning and teaching in terms of Technology Enhanced-Learning (TEL) [4]. It has been increasingly used in developed countries (i.e. USA, UK, and Europe). On the other hand, several countries including those in the Middle Eastern and northern African (MENA) regions, have still not adopted the technologies into their education system, or have not fully developed them [5].

In the Science, Technology, Engineering, and Math (STEM) education fields, laboratories are an important educational resource for students. It’s in these laboratories that students acquire experimental skills. Nevertheless, there are some constraints in hands-on laboratories, especially in engineering and science fields, such as time limitations, safety concerns, an increasing number of students, and a limited number of available laboratories, among others. Therefore, setting up a new laboratory at an institute or university in some region, for instance the MENA region, may be expensive in terms of the initial investment and long-term maintenance [5].

Recently, several Remote Experimentation Labs (RELS), (belonging to both Remote and Virtual lab (RVLs) categories), have been set up to support hands-on experiments and increase the number of available experiments for students to carry out remotely. They seek to serve students and teachers and complement existing hands-on physical labs. In general, the interaction in RVLs can be similar to that happening in the hands-on laboratories with the only difference being that the experiments in hands-on laboratories are performed physically. RVLs can be performed via the Internet by providing many functional requirements that help to extend them with new experiments and features such as authentication, user management, and federation [6, 7].

This paper presents the REXNet project which is a collaboration among three universities (i.e. Duhok University (UoD), Zakho University (UoZ), Duhok Polytechnic University (DPU)) in Kurdistan Region-Iraq as well as Oklahoma State University (OSU) in Oklahoma, United States. This research is supported by the International Research & Exchanges Board (IREX) organization with the primary goal of the project being creation of distributed laboratories (Modules) for collaborating in various experiments among universities via the Internet by identifying action initiatives that make up education system for the twenty-first century. In general, REXNet project calls for an increase in the number of tenure-track staff who are interested in using several technologies in their circular, as well as increasing the collaborative and cooperative work around technologies among researchers in the MENA region and specifically in Iraq [8, 9]. Additionally, it increases the access to remote experiments for students, without a significant cost.

The remainder of this paper is structured as follows. Section two outlines the RELs with a few examples of the RELs. Section three is a brief description of the REXNet project (e.g., Architecture and Modules). Section four contains a conclusion and the future work planned.

II. REMOTE EXPERIMENTATION LABS

Currently, traditional methods, such as chalk and talk, cannot acquire the results when compared with revolutionary teaching methods that are available with technology usage. The students need modern teaching methods to interact and to be encouraged. When using modern teaching methods, the boundary time is decreased and students can focus on the resources that are available on the Internet. However, it is possible make the teaching methods engaging through internships and collaborations and allow the students to interact with the real world for including the economic and social spheres [10].

In hands-on labs, the user interacts directly with the equipment by performing physical actions with their hands and then receiving a feedback [11], as shown in fig 1. REL’s use Information and Communications Technology (ICT) to conduct and perform the experiments with real devices or simulated real devices remotely [10, 11] as shown in fig.2.

![Fig 1. Hands-on Laboratory](http://example.com/fig1)

![Fig 2. Remote Experimentation Labs Architecture](http://example.com/fig2)

Today, several RELs have been implemented for students and teachers, in the field of science and engineering around the world, for example Virtual Instrument Systems in Reality (VISIR) and VLab. Some of them were awarded the best remote controlled laboratory by the Global Online Laboratory Consortium (GOLC) and some of them have been financed by different international programs.

Nowadays, instructional technologies, such as RVLs, have become important in the science and engineering disciplines. Varieties of RELs have been installed at different institutions for educational issues [13]. Therefore, it seems that RVLs have been widely used in education systems and provide information of educational theories to students and teachers.

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1. [http://cs.okstate.edu/irex/index.html](http://cs.okstate.edu/irex/index.html) (Use IE Explorer or Mozilla browser)
2. [http://cs.okstate.edu/~avgupta/IREX/](http://cs.okstate.edu/~avgupta/IREX/)
3. [https://physicslabfarm.isep.ipp.pt/](https://physicslabfarm.isep.ipp.pt/)
4. [http://vlab.co.in/](http://vlab.co.in/)
5. [http://www.online-engineering.org/GOLC_online-lab-award.php](http://www.online-engineering.org/GOLC_online-lab-award.php)
6. [http://www2.isep.ipp.pt/visir/](http://www2.isep.ipp.pt/visir/)
III. REXNet Project

A. Architecture

The architecture of the REXNet project is experimental in practice with aims to develop labs, tools, and frameworks. REXNet’s approach is of practical operations on new forms of learning in Iraq by building several modules of experiments. These modules have been created by using a 3D Unity platform. The REXNet project involves a computer server in the servers at OSU, which hosts the modules of experiments allowing students to perform and run these experiments remotely from their own computer via the Internet, as illustrated in fig. 3.

Fig 3. A general architecture of REXNet project [14].

B. Virtual Learning Environments (VLEs)

The REXNet project involves adoption of Virtual Reality Based Learning Environments (VRBLE) [15]; these lab modules are available to Iraqi universities, specifically universities in Kurdistan. It was a project funded by the US based IREX organization with aims to serve higher education teachers and students in Iraq by including several modules of virtual robotics learning related experiments, which have been developed at OSU. The modules developed can be accessed remotely by students in different locations and are comprised of learning components termed as Virtual Learning Environments (VLEs). VLE based learning is considered to be one of the most promising of next generation cyber learning environment approaches which is expected to revolutionize educational practices [16]. VLE based teaching approaches hold the potential to impact student learning in a substantial manner and can overcome some of the drawbacks of traditional teaching approaches [16]. For many years now, educational experts have recognized that the traditional teaching approaches do not work well with various types of student learners. Student learners can be categorized based on various learning styles including visual, kinesthetic, and auditory learners. VLEs hold significant potential to support visual and kinesthetic types of student learners as well as active learning by allowing students to learn through virtual experimentation and interactive ‘hands on’ activities through the use of cyber technologies. For example, imagine being able to learn an engineering assembly concept through a 3D lab based environment virtually by interacting with digital 3D mockups of robots, conveyors and machinery through the Internet. In such approaches, students will be able to actively interact with the help of teaching avatars (see fig. 4), grasp the fundamentals, and learn using simulation modules that mimic physical environments. Further, students can repeat the learning interactions until they have grasped a specific concept or principle. They can propose solutions to given problems, compare alternatives, and see their impact of their engineering decisions.

VLEs are typically created using 3D Virtual Reality technologies involving both software and hardware to support various levels of learning immersion. There are 3 types of immersive environments: non-immersive, semi-immersive, and fully-immersive [17]. The emphasis in this project is to create non-immersive environments which will allow students to learn interactively from remote locations. The educational scope of this project deals with the field of robotics and encompasses fundamental and advanced concepts in robotic assembly (at various levels of abstraction), algorithm based assembly planning, path planning, and obstacle avoidance. An ancillary focus is to create a VLE module which will teach the students how to create such Virtual Reality based research environments. The term “module” refers to a learning unit, which has specific learning objectives. Avatars and other interactive features are incorporated into the VLEs being developed to make for more efficient learning and user friendliness. An example of a VLE is shown in the fig. 1 including an avatar (in the lower left side) which can help students to interact with the VLE.

C. Modules

In general, the REXNet project aims to use a Virtual Lab Environment for serving students and teachers of computer science and Physics departments from those three universities. It is composed of several learning modules of robotics (i.e. Revolute Arm, Gantry, Automated Gantry, Auto W/point Picking, Factory, and the A* algorithm)

- Revolute Arm Module.
This module shows several colored buttons on the screen, which are used to control the robot’s arm movements. The buttons are color coded so that they match the part of the robot that they control. Each part has two buttons that move the part in opposite directions. The directions indicated on the buttons are relative to the view, not the robot’s. For instance, if a button is labeled “Left,” then that button will rotate the robot part towards the left, as shown in fig. 5.

The buttons Reset and Main Menu, which are in corners, can be used to move all robot parts back to their default positions and back to the main hub, sequentially.

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- **Gantry Module.**

This module includes three camera views of the robot: a front view, a top view, and a side view, as shown by fig. 6.

The controls for the simulation are located at the top and bottom of the window for the front camera. There are several controls that can be used in the simulation:

- Below the title are input fields; by typing in these fields, the location of the part can be changed. Once the numbers are entered, the user must press [Enter] in order for the location of the part to change.

- There are also two rows of buttons available at the bottom of the screen: The -X, +X, -Y, +Y, -Z, and +Z buttons are manual controls used to control the gantry. Notice that they are color-coordinated to match the parts of the gantry that they move. Each click on these buttons will move their respective parts 0.1 units in the designated direction.

- Once the gantry is in position to pick up a part, the Grab Part button can be used. Notice that if the gantry is not close enough to the part, the simulation will not allow for the part to be picked up. The input fields will turn green if the gantry is in the correct position to pick up the part. All coordinates for a single part must be green in order for the gantry to pick up that part.

- Once it has moved the part to the desired location, the Release Part button will drop the part. However, the part must be released onto the surface of the assembly area, or else the gantry will refuse to drop the part.

- The Reset button is used to return the gantry to its position and move the parts back to their default positions.

- The Main Menu is used to return to the virtual lab hub.

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- **Automated Gantry Module.**

This module is similar to the previous one but its main difference is that it utilizes automatic assembly by focusing on manually controlling the gantry, as illustrated in fig. 7.

In the bottom left corner of the screen, there are three input fields that are colored blue, green and orange. These input fields control the order in which the automatic assembly grabs the parts. Each box controls the corresponding part that matches its color and has input fields with a range of 1 to 3. If duplicates are entered into the boxes, then the duplicates will become red in color until the error is corrected, preventing the assembly from beginning.

At the bottom left corner of the screen are three buttons with the following functions:

- The “Begin Assembly” button is used to initiate the simulation.

- The “Reset” button is used to move all the parts back to their initial position and reset the gantry.

- The “Main Menu” button is used to return to the main menu.
Below fig. 8 in the front view, there are four white boxes with several labels. These boxes are the input fields for entering the coordinates that the gantry can follow on its way to the part. If obstacles are in the way, it must move the gantry around the obstacles. These labels are as follows:

- P1 indicates the first point that the gantry moves to on its way to the part. This point should be set in order to avoid obstacles.
- P2 indicates the point where the gantry should be moved in order to pick the part up.
- X and Z indicate the axes that the coordinates belong to.

For using this module it requires the use of these input fields to move the gantry towards the part in an efficient manner. Values for these input fields can be estimated by using the scales provided within the camera views. Note that all fields must contain a value or else the assembly will not start. In addition, if the values of P2 are not accurate enough, the gantry will refuse to pick up the part and the simulation will end. If the values of P2 are wrong, you must reset the simulation and place new values into P2 until the part can be picked up.

This module simulates a factory assembly by including three input fields colored blue, green, and orange. These stations located on the left corner of the screen are called "Part Assembly Order", as shown in fig. 9.

These input fields control the order in which the automatic assembly grabs the parts. Each box controls the corresponding part that matches its color. These input fields have a range from 1 to 3 and if duplicates are typed into the boxes, the boxes with duplicates will become red in color until the error is corrected. Entering duplicates will also prevent the assembly from beginning.

On the left corner of the screen there are three buttons. These buttons have the following functions:

- The “Begin Assembly” button is used to initiate the simulation.
- The “Reset” button is used to move all of the parts back to their initial position and reset the gantry.
- The “Stop” button is used to stop and read the time of the simulation.
- The “Main Menu” button is used to return back to the main menu.

The goal of this module is to optimize the assembly time by creating a part assembly order to minimize the assembly time. A timer (located at the top of the “Right” window) is used to track the current assembly time. Each part slows down the assembly by a certain amount so that it must attempt multiple part orders to determine which parts cause the most and least decreases in speed.
Fig. 9. Factory Module Interface

A* Module.

This module simulates A* search algorithm by clicking on "Generate Course" button. The two numbers will be selected randomly. Afterwards, when click on the "Find Path" button the module will show the path between those two numbers, as shown in fig. 10.

Fig. 10. A* Module Interface

IV. CONCLUSION AND FUTURE WORKS

RVLs not only enhance education in the universities and institutions, but they also increase the teacher’s and student’s qualifications and skills. They have been widely used by teachers to assist the curriculum and in turn have become the main resource for students to achieve results today.

RVLs are a useful tool for universities who have limitations in resources and equipment in their hands-on labs. RVLs allow teachers and students to run the experiments via the Internet anytime and from anywhere. This technology has become a good tool for supporting Hands-on labs, but will not replace it.

Overall, this paper is presents a new project with several modules of experimentations, which is called REXNet project. Modules of REXNet project are comprised of learning components called Virtual Learning Environments (VLEs) which are considered one of the most promising of the next generation cyber learning environment approaches. Currently, the REXNet project is available to teachers and students from Iraqi universities for teaching. It is involved in the Remote Experimentation course for senior students at the University of Duhok, computer science department, in the academic year 2017-2018.

REXNet project includes six modules that can be viewed as Virtual Lab Environments for students and they can access these modules from their personal web browser remotely. Further, the term “Module” refers to a learning unit, which has specific learning objectives such as:

1. Allow students to access the RELs remotely
2. Create a Local Community of Practices (CoP) around instructional technologies (e.g. RELs and Virtual Reality “VR”) in Kurdistan Region [9].
3. Increase the collaborative and cooperative work among researchers in Iraqi universities [5].

Today, the REXNet project can be another opportunity to the MENA universities for increasing collaborative and cooperative work among their researchers and developing students’ skills in STEM disciplines.

Right now the REXNet project is available for free access (without credential online login) and future work will be focused on:

- Integrating REXNet into Learning management system (LMSs) for creating an online credential login.
- Involving other universities from inside and outside of Iraq to use REXNet modules.
- Evaluating the REXNet modules on students’ performance.

Moreover, teachers must be educated in using instructional technology such as RELs to teach students and should continue to provide the students with other technologies, for example Virtual Reality (VR), for enhancing their skills and developing higher education system in Kurdistan Region and Iraq.

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