EFFECTIVENESS OF E-LAB USE IN SCIENCE TEACHING AT THE OMANI SCHOOLS

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ABSTRACT
Computer and information technology can be used so that students can individually, in groups, or by electronic demonstration experiment and draw conclusion for the required activities in an electronic form in what is now called "e-lab". It enables students to conduct experiments more flexibly and in an interactive way using multimedia. It helps them to achieve electronic practical training, skills, and tendencies. This paper focuses on describing the design and procedures of a nation-wide research project financed by The Research Council and conducted to measure the effectiveness of the e-lab on Omani students' acquisition of practical abilities and skills. The research project, in particular, examines the effectiveness of the e-lab in science teaching, the skills acquisition, and basic education students' appreciation of classroom environment. It also aims to know the students' attitudes towards the use of e-Lab technology and its employment. The paper will draw prospective recommendations for the field work derived from literary evidence.

Keywords: e-lab, Oman; science education; practical skill; technology

1. INTRODUCTION

Last decades have witnessed unprecedented revolution in the field of technological applications specifically in the teaching and learning process. Technology has become an essential component of this process in a way it does not affect the teacher, student or course materials but it connects all these elements and makes the output of the educational process of high quality. In particular, science education was greatly affected by technology in terms of the nature of the laboratories' work, equipment, and media.

Many methods and tools used in the traditional lab no longer meet the needs of learners for many reasons. There is a need to activate and utilize the latest technological techniques to achieve effective science teaching/learning process. By using innovations facilitated by the possibilities of information and communication technologies in science education and practices, we can utilize the advantages of safe interactive learning that simulates real laboratory work.

2. LITERATURE REVIEW

Technology integration in teaching and learning process is no longer a luxury but has become a vital requirement to develop educational infrastructure/structures. Technology offers qualitative leap in reformulating all educational process components. E-Learning technology and its applications have become an integral part of communities' lives. A set of applications in education such as: mobile learning, virtual reality and electronic museums have begun (Sharples et al., 2007). The use of technology implies great importance and many advantages, including:

- Dealing with some of the phenomena that are difficult to apply in a traditional laboratory.
- Implementing many difficult and dangerous experiments through simulations.

In the following sections, we will review literature on the concept, definition, importance, types, and obstacles of e-labs.

2.1 Concept and Definition
Science education is closely linked to experimentation and laboratory work. Recent literature confirms the important role of experimentation in increasing students' active and vital participation in the learning process, as well as it helps students to acquire different skills and form positive attitudes towards science learning (ICSU, 2011).

Laboratories developers have focused to take advantage of computer applications to create safe/active interactive learning environment that simulates lifelike e-laboratory. This lab 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" (Hatherly, n. d.). It can be defined as "a tool consists of interactive computerized software linked with sensitive connector endings called sensors, where the components of practical sciences experiments are integrated with computers as a measurement instrument to collect and analyze data." (Al-Shaiey, 2006).

2.2 Objectives
Objectives of e-labs are as follows (Shaheen and Khattab, 2005, p. 206):

- Update laboratory work and its applications to keep pace with technological advances.
- Take advantage of computer in employing scientific and educational software in the educational process.
- Compensate for the shortfall in some laboratory equipment through the use of ready-made computer software.
- Help students to deeply understand scientific concepts.
- Correct many of the misconceptions held by students about science and technology.
- Develop students' positive attitudes towards the study of science and the use of technology.

2.3Components
E-lab consists of major components as mentioned in Al-Bayati (2006, pp 28-32):

- Laboratory devices and equipment: by integrating a number of traditional laboratories with some additions and enhancements necessary to help in their use inside the laboratory and e-lab.
- Computers and servers: e-labs need to provide a computer connected to the local network or the World Wide Web to enable individuals to work directly in the lab or remotely at any time and place as well as special software to access the network. Laboratory servers must be loaded with software and simulation programs that allow correspondence between individuals and devices.
- Communication network and hardware: in the case of conducting experiments remotely by connecting all users with the laboratory through digital communication, then all hardware interfaces should be connected with computer network and servers. Communication lines should be secured and highly reliable as required by the experiment in terms of capacity of the channels of communication. Users should be provided with a reasonable capacity of communication channels to enable them to communicate with the laboratory through a local network or the World Wide Web. It is necessary to provide these facilities with affordable cost in order to establish interaction between the users and the e-lab in which they can perform all the required experiments.
- Special e-lab programs: these can be divided into two types: the first through which the users learn to perform experiments and provide them with experiments requirements in terms of information and special program; the second manages laboratories by including special e-lab software and simulation programs prepared by specialists in this field in addition to the initial training of the users on how to use these software/programs to easily implement the required experiments.
- Participation and administration programs: the other part of the programs is related to how to manage the lab and the students/researchers participation. These programs register the students in the laboratory and determine the types of access rights that must be met for each user to work in various experiments. The importance of such programs lies in their ability to allow each group of students to work on the experiment according to certain levels such as allowing students to work at a certain stage on some experiments and devices that suit them. (Al-Shahri, 2009, p. 72).

2.4 Benefits and Advantages
E-lab is a revolutionary technologic way in the field of science laboratories through which the student is accustomed to computers not only as a means of calculation or information storage but as a laboratory tool used for measurement and control. Moreover, it becomes a tool to study and clarify the experiments and their relation to theory so the student can understand the meaning of conducting practical experiment while doing them. The

student can use the e-lab as a means to conclude the laws through real measurements during the experiments. Therefore, e-lab serves as a tool to understand and convince through viewing, experimentation and conclusion. Other benefits can be summarized in the following points (Zaitun, 2002, p.164):

- E-lab is an excellent substitute for traditional laboratory as it offers students experience of skills close to the direct experience.
- It contributes to overcoming the obstacles that prevent the students from conducting actual experiments.
- It provides learners with an interesting interactive scientific environment.
- It allows students the possibility to conduct scientific experiment step-by-step with immediate feedback.
- It enriches curricula by providing students with experiences that would be too hazardous or prohibitively expensive in a conventional setup (Coble, et al., 2010)
- It can use unique visualizations to provide insight not available in conventional labs; this is particularly the case for phenomena that are not directly observable (Coble, et al., 2010).

2.5 Types of Integrated Technology

There are several types of integrating technology in laboratory practices (Zaitun, 2002, p. 165; Farooq et al, 2013):

- Computerized science labs: two-dimensional treatment that relies on sensors for testing and conducting experiments. It includes the design of a number of laboratory experiments available on computers or stored on DVDs and CDs. This type does not provide the proper atmosphere for the student to engage into the electronic environment.
- Online simulation labs: traditional two-dimensional laboratories containing labs' experiments, offering a number of experiments and experiments in the form of video clips. This software is available on the Internet so that anyone in the world can watch and deal with them. However, the level of the learners' interaction with the experiment elements and their ability to change them is limited.
- E-laboratories: aim to provide practical experiments closer to reality. The programs are presented in two-or-three dimensional forms accompanied by sound, image and movement. Their environments/components are modifiable and controllable. They offer a great deal of interaction between the student and the electronic environment and enable more than one person to navigate in the lab and interact with others.
- Three-dimensional e-laboratories: software simulation of real experiments. They are similar to the previous e-laboratories but they use new presentation technologies such as: head-mounted display, data glove, and tracking system. They allow the student to engage in such VR environment. They provide three-dimensional panoramic presentations associated with three components: eyes, ears and hands. Attempts continue to link all parts of the body through a full body dress that connects senses and nerves areas with feedback devices to make direct contact with the skin surface of the user resulting in a complete and direct individual interaction with electronic reality experiment.

2.6 Obstacles of Use

Obstacles to the use e-labs are (Zaitun, 2002, p. 165):

- It requires computers and equipment with special specifications for clear representation of complex phenomena.
- Its design and production need a specialized team of experts in computers, curriculum and psychology; and specialists in different branches of science.
- E-labs rely on languages (specifically, Arabic) are still rare.

3. PREVIOUS STUDIES IN THE ARAB WORLD

There are many studies related to e-lab, its role and importance in the Arab World. In this section, we will present findings of some of these studies.

- Al-Mutairi study (1998) entitled "the impact of using science computer software on the achievement of sixth grade students. The researcher used the experimental method with a sample consisted of 60 students distributed to a group of 20 students studied using a computer software and another group of 30 students studied using the traditional method. The study showed statistically significant differences in student achievement between the two groups in favor of the group that studied using the computer software, in memorization and understanding levels, but did not show differences in the level of the application.
- Al-Anzi, study (2003) entitled "the impact of using online science educational unit on the achievement of second preparatory class students". The sample consisted of (30) students as experimental group

using online science educational unit, and (30) students as a control group. The main results showed significant differences between the achievement means of the experimental and traditional groups in levels of memorization, understanding, and application; and between the two groups in the overall level of post-test in favor of the experimental group.

- Al-Shaiey study (2006) entitled " Status of using computerized science labs at secondary stage and teachers/students' attitudes towards them". The study used the descriptive method and included 118 teachers and 580 students. The main results showed that 37.7% of the teachers sample did not use computerized science laboratories at all, whereas 62.3% used them once at least during the semester. There were positive attitudes among the teachers and students towards these laboratories with statistically significant differences in teachers' attitudes in in installing, using, and teaching through computerized labs. Statistically significant differences existed in favor of teachers and students attitudes towards these labs in favor of highly skilled students in the use of computers.
- Saleh et al study (2004) entitled "the Effectiveness of computer simulation programs on the achievement and laboratory skills acquisition of students at the secondary level". The results indicated the effectiveness of simulation software, when used alone to achieve the instructional objectives related to the achievement and laboratory skills.
- Shabbat study (2005) entitled "the effectiveness of electronic computerized training and its adequacy on some biology laboratory experiments in the second secondary class of Daraa province and its impact on student achievement and their attitudes towards it. The researcher used the experimental method and prepared a questionnaire especially for the sample of the experimental group to find out their attitudes towards the e-lab. The study sample consisted of two groups (24 students) experimental studied in computerized training environment, and (24 students) studied in a traditional laboratory. The findings showed statistical differences between the mean scores of the two groups in the overall post-test in favor of the experimental group with positive attitudes among students towards the use of biology e-labs.
- Al-Qarni study (2006) entitled "the impact of using computer simulation in teaching science on scientific concepts achievement among students of Bisha governorate second preparatory class". The researcher produced a computer simulation program and applied a pre-post achievement test of scientific concepts as a tool for the experimental study. The study findings showed that statistical differences between the mean scores of students of the two groups on the achievement of scientific concepts in posttest at three levels of: memorization, understanding, and application in favor of the experimental group.
- Al-Shannaq et al study (2004) entitled "the impact of using the dry laboratory strategy on the achievement of science students at the University of Jordan". The researchers used the experimental method with a sample consisted of 142 male and female students who were divided into two groups, experimental (84) students and control (59) students. The findings showed statistically significant difference at the level of (0.05) in academic achievement in favor of the experimental group.
- Al-Khalaf study (2005) entitled "the effect of using the dry and wet laboratory in teaching chemistry on the achievement of the basic ninth class students and the performance of their science processing skills". The study sample consisted of 116 students divided into two groups: experimental (57) students and control (59) students. The researcher prepared achievement test and a dry laboratory software. The results showed statistically significant differences in student achievement in favor of the experimental group. The study also showed statistically significant differences attributed to the impact of interactive between teaching method and gender in the achievement test, and in the performance of the science processing skills test in favor of experimental group. A positive statistical correlation between achievement and performance of science processing skills in both groups.
- Al-Radi study (2008) entitled "the effect of using virtual laboratories technology in chemistry on the achievement of the third secondary class students of Qaseem region". The study used quasi-experimental approach. The study sample consisted of 85 students and divided into two groups: experimental (43 students) taught using e-lab and control (42 students) taught using traditional lab. The researcher constructed an achievement test as a tool for the study. The results showed a statistically significant difference between the experimental and control groups in favor of the experimental group demonstrating the effectiveness of the e-lab in improving achievement.
- Al-Balushi study (2009) entitled "the effectiveness of chemistry e-lab on the development of practical skills and achievement of students at the post basic education in the Sultanate of Oman and their attitudes toward it". The researcher used the quasi-experimental approach. The study sample was (120) students from the eleventh grade of post education stage equally divide into two experimental and control groups. The researcher prepared an achievement test, an observation scheme, and an attitudinal

scale with other training materials and guides as study tools. Findings showed statistically significant differences between the mean scores of pre-posttest in terms of academic achievement in the experimental group in favor of the posttest. They also showed statistically significant differences between the mean scores of the experimental group and the control group in the observed practical skills in favor of the experimental group. Both results demonstrate the effectiveness of the e-lab to improve the achievement level. Statistical significant differences were also found between the mean scores of pre-post application of the attitudinal scale toward chemistry e-lab in the experimental group in favor of the post application demonstrating the positive attitudes towards this lab.

- Redha study (2010) entitled "effective use of e-lab for enquiry and demonstration in teaching chemistry on the development of scientific thinking". The researcher used quasi-experimental approach. The study sample consisted randomly of 91 students distributed into three experimental groups: (30 students) in experimental group (1), (30 students) in experimental group (2), and (31 students) in the control group. The researcher has designed a test of scientific thinking in chemistry and e-lab as study tools, in addition to enquiry and experimentation worksheets. The results pointed out the effectiveness of the e-lab investigating and demonstrating role in the development of scientific thinking. They also showed that the effectiveness of the e-lab varied according to its type in favor of the enquiry-based e-labs.
- Ahmad study (2010) entitled "the effect of using a e-lab on the physics concepts achievement, acquisition of higher-order thinking skills and motivation toward science learning among students of the third preparatory class". The researcher pursued quasi-experimental approach. The study sample consisted of 90 female students randomly selected from the third preparatory class and equally distributed to two: experimental and control groups. The researcher prepared study tools: achievement test in physics concepts and achievement test to measure the acquisition of higher-order thinking, and constructed a motivation scale towards science learning. The researcher used multi-media software adopted by the Ministry of Education in teaching 'sound and light' unit for the third preparatory class. The results indicated statistically significant differences in favor of the e-lab, where the study pointed out the effectiveness of the e-lab in the development of thinking skills in addition to raising the level of achievement in academic concepts. The results also indicated the impact of the e-lab in the motivation toward science learning.

Drawn from the previous reviewed literature and research, this paper focuses on describing the design and procedures of a nation-wide research project financed by The Research Council and conducted to measure the effectiveness of the e-lab on Omani students' acquisition of practical abilities and skills. In the following sections, we will describe the project objectives, study questions, research methodology and design.

4. PROJECT OBJECTIVES

The project short-term goals are as follows:

- Study the effectiveness of the e-lab in teaching science on a set of teaching-learning variables such as: academic achievement, science processes, scientific attitudes, attitudes towards the use of e-lab technology, estimation of the classroom environment, visual thinking, and laboratory skills among fourth grader students in basic education.
- Detect positive points and obstacles of e-lab employment at the basic education schools in the Sultanate of Oman.

In addition, the long-term objectives are as follows:

- Develop practical and mental skills of students in the science using e-lab.
- Encourage science teachers to employ modern technology in the field of science laboratories.
- Develop the scientific thinking skills and procedures among students through active electronic interaction.
- Develop teaching science through enquiry by employing e-lab in science lessons.
- Develop classroom environment that enhance science learning by employing e-lab.
- Develop students' attitudes toward studying science and its branches in basic and post education in Oman.

5. Project Questions

1. How effective is the e-lab on the basic education school students' achievement?
2. How effective is the e-lab on the development/acquisition of the followings among students in basic education schools: logical thinking; acquisition of science processes; scientific attitudes; visual thinking?
3. What are the attitudes among students in basic education schools towards the employment of e-lab in science teaching?
4. Are there statistical differences among students' attitudes towards e-lab in terms of gender, technological expertise, the scientific level?

5. Are there statistical differences among students' attitudes towards science in terms of gender, technological expertise, the scientific level?

6. RESEARCH METHODOLOGY

In this project, we will use quantitative research methodology in particular experimental design to measure the effectiveness of the e-lab towards the study variables (academic achievement, science processes skills, scientific attitudes, logical thinking, visual thinking, and attitudes towards e-lab)

6.1 The design of the research project

The research project examines the effectiveness of the e-lab in science teaching, the skills acquisition, and basic education students' appreciation of classroom environment. It also aims to know the students' attitudes towards the use of e-lab technology and its employment.

6.2 Study population and sample

The study population consists of all students who are studying science in the first basic education. The study sample includes (40%) of the research population in three Omani educational regions. The two groups (experimental and control) in each field treatment should be equivalent in the terms of study variables; and pre and post application. Each field experiment will have different type of e-lab: 3D, 2D, and online based labs.

6.3 Study Tools

To achieve the objectives of this study, the following tools were used:

1. Achievement test: the achievement test to be prepared by science teachers in light of the subject plan. It consists of questions item covering most aspects of the scientific material that is supposed to be studied by experimental and control groups' students. The total score is used as an indicator of a student's academic ability in science. The test is conducted and corrected, and students' scores are recorded for both groups by their teachers.
2. Science processes test: to measure the basic and integrated processes of science.
3. Attitudinal scale towards science: to measure the cognitive, behavioral and affective aspects.
4. Visual thinking scale: to measure the effectiveness of the e-lab in the development of visual thinking among the sample study.
5. Estimation of classroom environment scale: this is a scale adapted to the Omani context to measure the study sample estimation of the real and preferred classroom environment.
6. Practical skills test: to be prepared by science teacher in light of the subject plan. It consists of practical experiment covering most aspects of the scientific subject that is supposed to be studied by experimental and control groups' students. The total score is used as an indicator of a student's academic ability in science. The test is conducted and corrected, and students' scores are recorded for both groups by their teachers.
7. Attitudinal scale towards e-lab: this is a standardized scale. It consists of statements (negative and positive), with alternatives for answer (agree, neutral, not agree). Positive statements are given the following scores (1,2,3); whereas negative statements are given reverse scores (3,2,1).

6.4 Experimental design of the study

This study design adopts true experimental design with Pre-Post Test Control Group Design, where the experimental and control groups have to conduct achievement and practical tests. The experimental group is characterized by experimental treatment as it will be taught using the e-lab aided by teacher who should participate, be trained to use it, select what fits for the science lessons, and then implement it in the classroom. The students should use computer tablets to connect to the e-lab software and network while conducting experiments in the classroom (under teacher supervision). The following table is a summary of the design.

Table 1 Summary of research design

Group	pretests	experimental treatment	posttests
Experimental	achievement test science processes test attitudinal scale towards science practical skills test visual thinking scale Estimation of classroom environment scale	use e-lab in teaching	achievement test science processes test attitudinal scale towards science practical skills test visual thinking scale Estimation of classroom environment scale

Control	achievement test science processes test attitudinal scale towards science practical skills test visual thinking scale Estimation of classroom environment scale	use traditional methods in teaching (no e-lab)	achievement test science processes test attitudinal scale towards science practical skills test visual thinking scale Estimation of classroom environment scale

7. PROSPECTIVE STEPS FOR THE FIELD WORK

With an amount USD118,257.00 allocated by The Research Council to continue this research project in its second year, the research team plans to:

1. Contract an external experienced consultant to ensure the application procedures of the e-lab field work.
2. Prepare the research tools, tests and scales.
3. Prepare for the field application by:
   - contracting (3) science teachers in (3) schools from (3) different educational regions; and:
   - Installing the required technological infrastructure for the field work (e-lab, software, equipment, licenses…etc.).
   - Training the (3) teachers on the use of research tools and software.
4. Ensure the equivalency of the experimental and control groups.
5. Contract (8) teachers to help in data collection from the (3) schools.

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