Effectiveness of E-Learning in the Chemistry Laboratory: A Case Study of Undergraduate Chemistry Laboratory and a Proposal for High School

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الملخص

تؤثر الخبرات المكتسبة لدي الطلاب على عملية التعلم كون اكتساب المعارف الجديدة يعتمد على توفر المعارف السابقة لدى المتعلم. عدم تمكن طلاب الثانوية من اجراء التجارب المتعلقة بمنهج الكيمياء لذات المرحلة والسبب قد يرجع لعدم توفر المعامل في بعض المدارس او لعدم كفاية الوقت او المواد الكيميائية يؤثر سلبا على عملية تعلم الكيمياء العملية في السنة الجامعية الاولى. وللتغلب على ذلك تم تزويد الطلاب بمصادر تعلم بصرية، فيديو، صور فوتوجرافية وغيرها لمراجعتها قبل اجراء التجربة والتي تساعد الطلاب على الاستعداد الذهني للاستيعاب. وعند تقييم هذه الطريقة تبين انها تدعم فهم الطلاب. ومن خلال الاستبيان كان موقف الطلاب ايجابيا نحوها. كما تبين من خلال ملاحظة اداء الطلاب ان هنالك تحسن في ثقة الطلاب بقدراتهم على اداء التجارب عند تزويدهم بالوسائل البصرية. القسم الثاني من البحث المقدم يتناول مقترح استخدام الوسائل البصرية لدعم تدريس الكيمياء العملية في المرحلة الثانوية.

الكلمات المفتاحية (الدالة): التعليم الالكتروني، الكيمياء العملية، المرحلة الجامعية، المرحلة الثانوية.

Abstract

Students' previous knowledge influences their leaning process as the new concepts are built on the previous knowledge. The limited laboratory time or the lack of chemistry laboratories at high schools (secondary schools) is considered to influence the teaching process of first year at university in general chemistry laboratory. To overcome this, pre-laboratory visualization resources mainly videos, images and photographs resources have been utilized as a strategy for students' mental preparation prior to the experiment performance. The evaluation of the strategy shows that students had positive attitude toward its application and their understanding had been enhanced. Our experience noticed that students had confidence in performing laboratory work after introducing the strategy. In the second part of this paper, we proposed a visualization resources strategy to be used as a substitute for a practical work in the schools that lack the laboratory or limited time of laboratory.

Keywords: e-learning, chemistry laboratory, undergraduate, high-school

1. Introduction

E-Learning, defined as an Internet-enabled learning process, is becoming an increasingly important part of higher education (Gunasekaran, et al., 2002). It is moving more to be an effective and successful tool in a learning paradigm (Barr & Tagg, 1995). Some studies showed that e-learning is appropriate for teaching and learning (Kekkonen & Moneta, 2002; Hofmann, 2002). For e-learning to be successful, an effectiveness system providing sufficient knowledge needs to be developed (Lau F & Bates J, 2004; Quinnell, 2009). Thus, various Web-based learning systems have been developed for higher education. For example, Web Course Tools (WebCT), the Web Course Homepage System (WebCH), Blackboard Learning System and the System for Multimedia Integrated Learning (Smile), are the latest waves of technology-based learning and teaching tools

When the students start their university life, their previous knowledge influences their learning abilities. Generally, the difference in the previous knowledge is due to the substantially different school careers and other causes. Specifically, the level of chemistry practical experience with which students enter university is variable. This is considered to be a major factor affecting teaching process at the first university year, freshman. The extent of this difference depends on their school practical background, the availability of chemistry laboratories at high schools, availability of materials, and cost of equipments required performing the experiments and lack of classes for chemistry laboratory. In addition to that is the availability of teachers who is effectively capable of using laboratory applications. As a result the level of teaching general chemistry laboratory at university could be deeply affected by the pervious knowledge at his school life. It was noticed that students' performance in the laboratory can be enhanced if they are familiar with the background of the experiments which will be conducted (Johnstone, 1997; Patterson, 2010).

Laboratory classes usually start with an introductory lecture and/or demonstration, at the optimum. From instruction point of view, this requires that the instructor explain

the information related to the subject of the experiment. For students to understand, it requires that they should have specific basic information and simple skills that they would learn at high school level. Some students have a good practical background while others do not acquire the necessary information. This way it is difficult for instructors to manipulate. If students for example do not understand how to construct the simple experiment apparatus, they would perform the experiment badly and miss to learn the objected aspects (Johnstone, 1997) since they focus instead to learn what they should learn at their high school years. Thus, students missing the essential information, usually follow mechanically instructions from the laboratory book, word-by-word to perform experiment.

A mechanism whereby students could gather the important knowledge in theory and practical aspects is essential (Saribas, 2009). Therefore, to improve and refresh the previous knowledge, many researchers suggested a different kind of pre-laboratory strategies before they start their practical work. Literature review reflects that pre-laboratory exercises pre-laboratory quizzes, and assignments and problem-based learning (Domin, 1999; Carnduff & Reid, 2001; Donnell et al., 2007). Also, in order to improve students' preparation before they start their practical work, pre-laboratory questions on the experimental procedure were suggested (Pogacanik & Cigic, 2006).

All of these strategies could enhance students to be mentally prepared. However, if they would be provided with basic skills of chemistry laboratory at high school level, their understanding would be better. To tackle this problem and provide our students with a channel by which they could gather the necessary theory and background as well as to get familiarity with some tools or equipments, students could be provided with some visual aids materials through electronic WebCT. The e- materials involves videos, Photographs, images and others documents that were available for students electronically so that they can watch them any time at any place.

This paper presents the results of a study in which visualization resources were used as a tool through WebCT to prepare and familiarize university chemistry students with the basic requirements to be ready to perform the university level experiments. In the second part of the paper, we propose for high school students, visualization resources

related to chemistry laboratory to be used in the schools that lack the chemistry laboratories.

2. Part I: Case study

This part is organized as follows. First, the research model and hypothesis are presented. Next, the research methodology used in this study is reported. Then, the results of the collected data and their analysis are discussed.

2.1. Problem statement

Some students, especially those students who studied at high schools in which the chemistry laboratory is not available, lack confidence and experience concern as they approach their first chemistry laboratory sessions at university. Those students do not have the basic experience related to basic laboratory techniques that they should have during their high school.

2.2. Purpose of the Study

The purpose of the case study part is to introduce the results of the application of video, image and photographic resources, through WebCT which could enable students to access at any time and place, and to repeat as many time as it is required. With this, the main objectives are to ensure that students prepare for forthcoming experiment, and are informed of basic requirements of the theory and processes involved. Participation is mandatory; online data capture the name of prepared students.

2.3. Hypothesis

Our hypothesis that we created to evaluate the study is that “the using of materials including videos, images and photographs can not enhance students’ background knowledge”.

2.4. Methodology

This study was conducted at King Fahd University of Petroleum & Minerals, Kingdom of Saudi Arabia. The study had been conducted in the period 2008-2009, during three semesters. Students were of general chemistry laboratory, first year. To achieve the mentioned objectives, the materials related to each experiment had been uploaded into the WebCT. Then, before each experiment, the students taking the first semester course in introductory chemistry laboratory were asked to watch the videos and review the material related to that experiment. Material of each experiment was involved a pre-laboratory quiz that had to be done before the performing of the experiment. Students were given access to the material for a particular experiment one week before they would meet in the laboratory. The first-year general chemistry laboratory course contains eleven experiments and the material was provided for each as shown in Figure 1. As a control based, visual aids of three experiments were hidden. Here as an example, figure 2 shows the print screen of the material related to preparation for experiment number seven. For each experiment, student had to solve a quiz after they review the material. Figure 3 shows an example of the quiz related to one experiment.

2.4.1. Data collection

The research methodology was based on the empirical data collected through a questionnaire survey.

2.4.2. Data analysis

The analysis of the results of questionnaires showed that the majority of the students have positive attitudes towards the strategy. Details of the percentage response and statements are summarized in Table 1. In addition, they have been asked if watching the materials was just a wasting of time or they could use their time more effectively. As shown in Figure 4, 25% of the response was the materials were just a wasting of time while 70% agree that they could use their time more effectively. Thus, our hypothesis that was created to evaluate the study is rejected “the using of materials including videos, images and photographs can enhance students’ background knowledge”.

Table 1. Percentage analysis of the students' response to the questionnaire

Statement	**Strongly Disagree %**	**Disagree %**	**Neutral %**	**Agree %**	**Strongly Agree %**
The material introduced in the WebCT were informative	0	0	0	80	20
The videos got me familiar with the basic requirements for the experiment	0	0	0	50	50
The material helped me mentally prepared for the experiment	0	0	50	30	20
It was easy for me to understand the demonstration by the instructor since the material that I had on the WebCT helped me to get familiar with the terminologies and names of the equipments	0	0	0	70	30
By watching the videos before attending the lab, I was able to get familiar with the purpose of equipments that I had to use inside the lab	0	0	40	30	30
Since I had no chance to attend chemistry lab at high school level, the material allowed me to compensate and enforce my previous knowledge	0	20	30	30	20
The materials were of no benefit	100	0	0	0	0
The course as whole fulfilled my requirements	0	20	40	40	0

I think that my learning have been better working with this strategy of pre-laboratory	0	20	30	40	10
I believe that I understood the theory behind the experiment before I enter the laboratory	0	0	30	50	20
By this strategy I had an opportunity to discuss with the teacher and others	10	30	20	40	0
Generally, I found the material useful	0	0	0	80	20

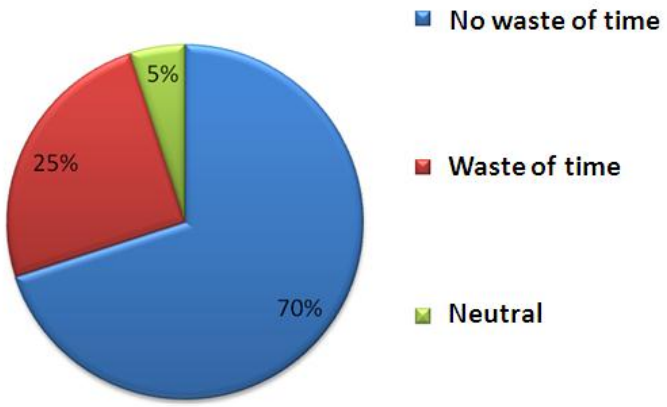

Figure 4. Shows the response of students when they were asked if the strategy wasted their time without gaining benefits or they could use their time more effectively

2.5. Advantages

Based on our results and experience, the pre-lab videos, images and photographs have provided various opportunities and have greatly changed the way students communicate in the laboratory. It enhances student-to-student and faculty-to student communication and offers a wide knowledge of general chemistry for the different needs and interests of students. Thus using this strategy would help to develop student-centered learning strategies. The Web provides an information learning environment accessible 24 hours a day. It is convenient and interesting for a student to learn new knowledge, seek information, gain feedback on assignments and communicate with teachers and other students via a web site. As far as students are concerned, students have personal control of information in the process of teaching and learning online. Also, it is easy access and learning at one's own pace and offer exciting opportunities to learners for greater participation, interaction and collaboration.

3. Part II. Proposal

3.1. Developing an interactive visualization resources for chemistry laboratory at high school

Some high school teachers in the schools that lack the laboratory do ask students, as activities, to do some simple home experiments. This is an attractive idea. However, providing students with videos to show them how they can do, will help to enhance their interest and thus ability instead of doing the assignment personally. Thus, the purpose of the part is to introduce a proposal aiming to develop materials, videos, images, photographs that can stand for chemistry laboratory for high school students. In case of computer is available, it could enable students to watch the experiments at any time as many time as it is required. Therefore, it will be possible for students to improve their knowledge and could be skills. Although the major target is students, the material can serve teachers as well. This well increase motivation and knowledge of teachers for teaching chemistry (Dalgarno, 2009) in a manner that is exciting and motivating.

3.2. Utilization

The videos, images and photographs could be used:

1. As a substitute for a practical lesson when the school lacks the laboratory.
2. As an aid to improve students observation
3. To support the development of students knowledge and practical skills.
4. As a substitute when the practical has not been successful in yielding the observations that might be expected.
5. As a revision resource so that observations can be revisited quickly.
6. As a revision resource when practical lessons can be revisited quickly.
7. As a stimulus to probe students understanding or ability to explain observations.
8. As a substitute for a practical work when time, lab access or fume cupboard access is restricted or for safety (Tawfik, 2010).
9. A substitute for a practical lesson when students have missed the practical lesson due to absence.
10. To support the development of teacher knowledge and practical demonstration skills

3.3. Methodology

The project has three phases. In the first phase, a survey will be conducted to determine the type of experiment that should be selected according to the assigned school text book. However, here in Table 2, we proposed general experiments that can be involved. Second phase involves the preparation of the materials. Final phase is the application and investigation of the effectiveness of the materials.

Table 2 Examples of proposed experiments

Experiment	Objective is to
Density Determination	practice techniques for determining volume and density of a substance.
Separation of Mixtures	prepare the mixtures and investigate how to separate the mixtures into components.
Boiling point of Compounds	explain boiling point of compounds
Acid, Base, or not identification	identify if a solution is acidic, basic or neutral
Physical & Chemical Changes	recognize and distinguish between chemical and physical changes
Preparation Solutions	prepare acid and base solutions
Flame Test	observe the characteristic colors produced by certain metallic ions when vaporized in a flame. Identify an unknown metallic ion by means of its flame test.
The Heat of Reaction	determine the heats of endo and exothermic reactions
Acid – Base Titration	determine the molarity of NaOH solution by titrating it with a standard HCl solution
Oxidation-Reduction Reaction	perform several reactions with metals to determine their relative strengths as oxidizing and reducing agents
Preparation of Aspirin	synthesize aspirin from salicylic acid and acetic acid
Preparation of Soap	prepare soap by the alkaline hydrolysis of fats and oils
Reactions of Glucose	test the reactions of glucose with $Cu(OH)_2$ and Ag_2O

3.4. Data Collection

The effectiveness of the materials will be investigated using pretest-posttest experimental research design at the high schools of the participant. The students will be investigated through their achievement level with the performance test, their attitudes towards chemistry and laboratory. Questionnaires and face-to-face interview can be also used for evaluation. The data will be analyzed via a statistical t-test.

3.5. Estimated Advantages

Based on the results of our case study, some advantage can be estimated. The students should start their university with good understanding of the material introduced in the high school level. The videos, images and photographs are expected to help them to understand the important aspects related to their subject. It can enhance high school students' knowledge and help improve their skills of scientific thinking and creative thinking. The advantage can also be to support teacher instruction sine it can stand as a substitute for a practical demonstration to improve student's observation.

4. Recommendations

The proposed technique provides a learning experience, and there may be some recommendations for further research studies to enlighten the results of the study. It is suggested that high school chemistry curriculum should involve the practical chemistry along with the theoretical knowledge related to chemistry. This study has some limitations to generalize the findings. Therefore, results from other universities might support the results or lead to different results. It is also recommended that the proposed technique be investigated in high schools.

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Appendix

Figures

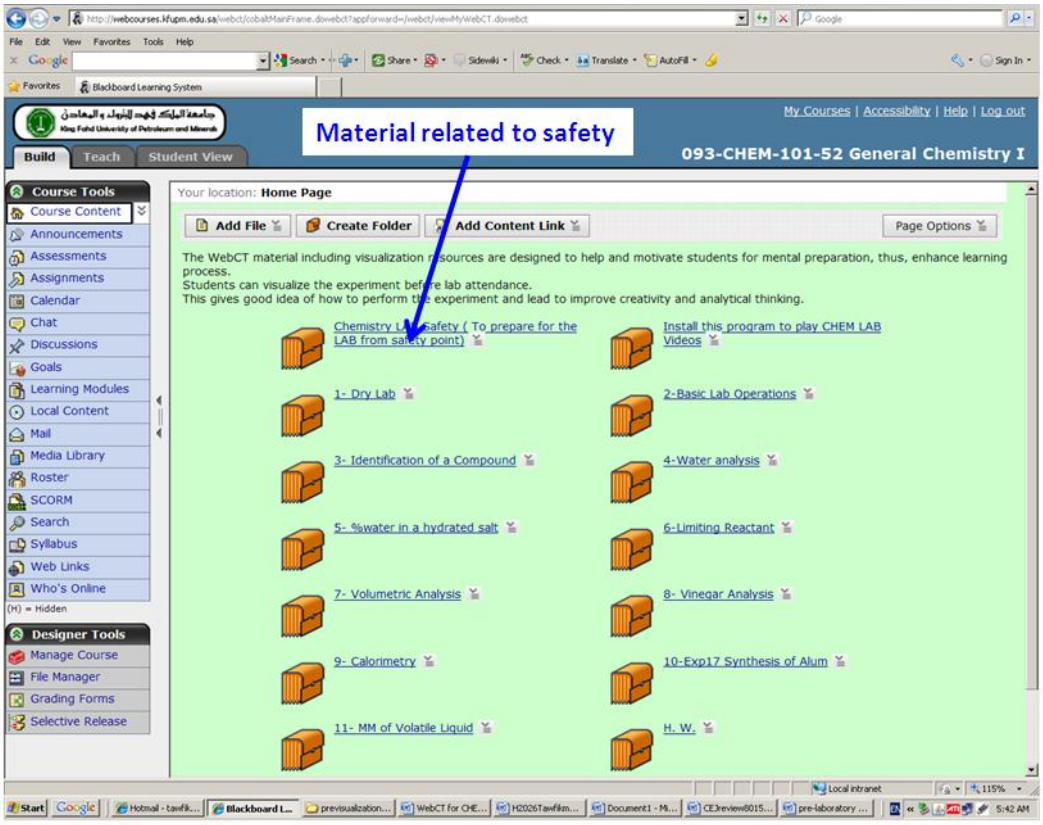

Figure 1. Screen capture the WebCT page

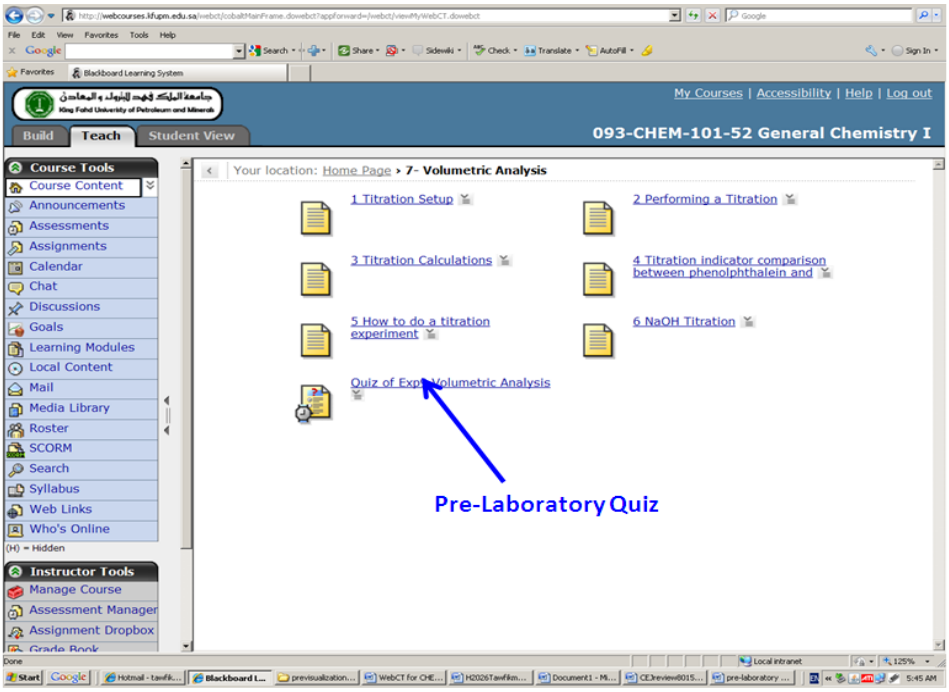

Figure 2. Screen capture the material related to an experiment

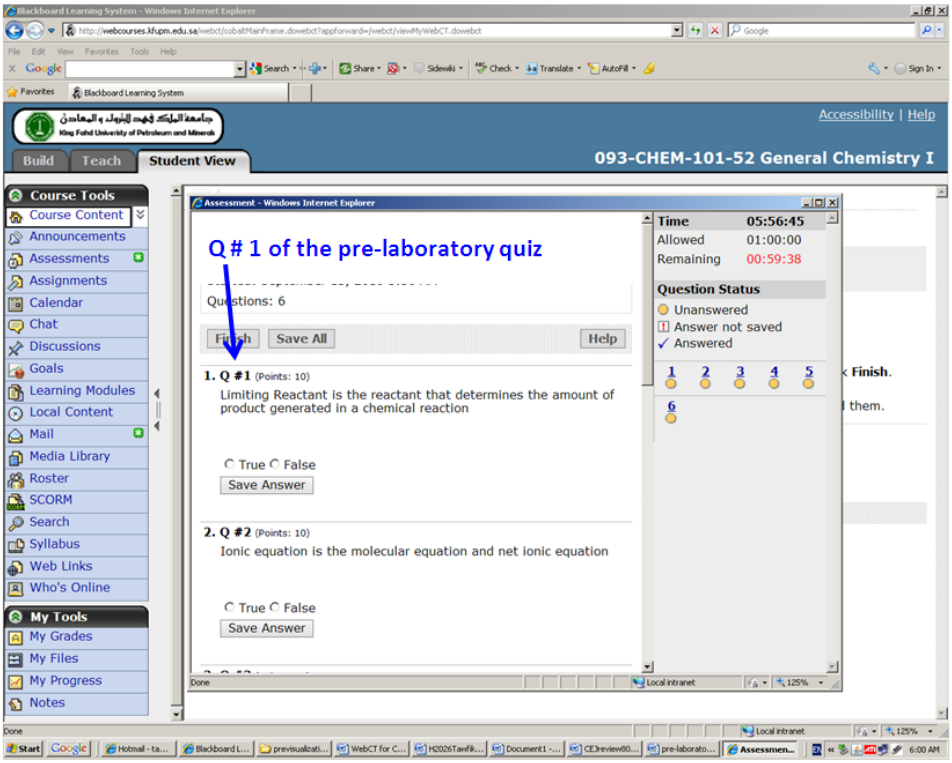

Figure 3. Screenshot of the pre-laboratory quiz