e-Learning Systems in Virtual Environment

Hatem Abdul-Kader
Faculty of Computers and Information, Menofiya University, Egypt

Abstract: *E-learning is one of the emerging needs of the information age. Therefore a lot of potential is seen in distance learning development. Virtual environment interface to e-learning systems have recently appeared on the Internet. Using virtual reality environment, the applications appear to be promising to e-learning tasks more nature and interactive. Also using this technology, it is possible to get a sense of three dimensional environments and level of user immersion. Extensible 3D (X3D) is the most common tool for building 3D viewing and browsing of e-learning systems. In this paper the benefits of virtual reality environment using X3D in e-learning applications are demonstrated. Those will be shown via implementing two web enabled virtual environment e-learning systems. The first one is an on-line virtual chemistry lab system. This application gives the student the ability to perform all experiments in a certain crucial. The second application is an on-line English language education system. This application gives the students the ability to learn the language audile and visual via on line interactive system. X3D is used as the main implementation tool which gives the systems users the full visualization and interactivity of all learning steps.*

Keywords: *e-Learning, virtual reality, virtual lab and, distance learning, and X3D.*

Received October 6, 2008; accepted May 17, 2009

1. Introduction

e-Learning is making connections among persons and resources through communication technologies for learning-related purposes. On-line learning in terms of this definition refers to activities that make connections among persons through the Internet for learning purposes. A large part of the growth in e-learning activities has been as result of the phenomenal growth of the Internet. The World Wide Web has evolved, as a universal platform to serve the information needs of a variety of clients across diverse geography and contexts [4].

Virtual Reality (VR) is a way for humans to visualize, manipulate and interact with computers and extremely complex data. The visualization part refers to the computer generating visual, auditory or other sensual outputs to the user of a world within the computer. There are three types of virtual realty systems, namely desktop virtual reality, fish tank virtual reality and immersive virtual reality. This classification is according to level of immersion. The applications of VR run a wide spectrum, from games to architectural and educational purposes. X3D is the standard file format for specifying dynamic and interactive (3D) virtual worlds on the Internet. X3D browsers are widely available for many platforms [4, 5, 10].

One of the most recent applications of virtual reality is the interface to e-learning applications [1]. Using this technology, it's possible to get a sense of a three dimensional environment of such web sites equipped with 3D object viewing. When users work with a 3D viewing capable browser then The powerful of 3D environment appears in the ability to view the whole environment in 360-degree with the ability to zoom your scene, and quickly navigate through the various places in your world and viewing your world through different viewpoints. The effect of 3D objects modeling appears in increasing the user attention and interactivity with the objects as in real world. For providing immersive environments (virtual classes and labs) where users can experience the navigation of virtual environment is both 3D and interactive, the standard language for designing such immersive environments is X3D. If the HTML language has been developed to design 2D (flat) Web pages, X3D can be used to exchange 3D information over the Internet [3, 9].

In this paper, the benefits of using virtual environments at e-learning applications are demonstrated, through building two types of virtual class using X3D language. Those virtual classes will be equipped with the designed web site which was constructed for distance learning purposes.

This paper is organized as follows; in section 2 an overview of related work and X3D language are discussed. The visualization interaction capabilities of X3D are discussed in section 3. The applications of virtual reality in e-learning are presented in section 4. Implementations of virtual environment labs are shown in section 5. Finally the conclusion is drawn in section 6.

2. Related Work and X3D

Virtual reality technology has been widely proposed as a significant technological advance that can offer a novel form of education. The potentials of virtual reality technology can facilitate learning process avoiding many problems characterizing traditional educational methods. Its primary objective is to provide highly realistic and believable simulations of virtual classes within a fully-immersive, interactive and three-dimensional virtual world. The educational benefit of these applications is the active participation of students in learning process. Moreover, students can observe or carry out virtual exercise and training, which are either difficult to be performed in a physical classes [2, 8].

Recently, a lot of research efforts have been made aiming to take advantage of the potentials that virtual reality and Web technologies offer at many educational subjects [8]. There are many e-learning educational systems were developed which use virtual environments. Medical and scientific subjects are the most common e-learning application that uses virtual reality technology [6].

X3D is a high level object-oriented language for the description of scenes and the behavior of objects. The syntax of X3D is based on objects (nodes) with parameters (fields). A number of nodes are responsible for the design of the scene: description of geometry, illumination of the model, materials and textures. Combinations of other nodes, i.e. sensors, routes and interpolators introduce dynamics. Sensors detect viewer actions (e.g., mouse move, click, and drag), time changes and viewer positions (visibility, proximity, collision). Routes direct captured events to interpolators to alter some fields (color, position, orientation, scale). While appropriate for direct animations, the mechanism is insufficient for descriptions of complex actions, e.g., the control of sequential clicks with the mouse on an object. In case of complicated movements and manipulations, the script node referring to Java applets and JavaScripts, may be employed. The proto node supplies the user with a tool to design his/her own sensors and interpolators. Common Gateway Interface (CGI) scripts embedded in the body of the X3D document allow establishment of connections to any application on the server. More details about the syntax of X3D can be found in [10]. Such systems are mostly implemented in three tier architecture as shown in Figure 1.

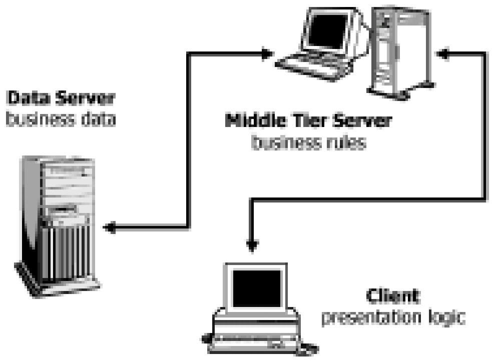


Figure 1. Three tier Architecture components.

The scene designed according to X3D is stored in an ASCII file. Specific visualization software, i.e., VR browser is necessary to display data on the screen. The role of X3D document and VR browsers is different. The X3D document supplies the parameters for scene design and the dynamics of objects while the VR browser takes care of scene rendering and the interface to navigate through and interact with the model. Initially, the basic function of the VR browser, besides visualization, was only real time navigation through the model, i.e., provision of virtual reality techniques: fly-over, walk-trough, pan and zoom. The second edition of X3D granted the VR browser with new responsibilities, i.e., detection of user interactions with objects if they were described in the X3D file. Plenty of freeware versions of VR browsers can be downloaded from the site of the 3D Web consortium [4]. An overview of X3D architecture and its components is shown in Figure 2.

The potential of X3D and VR browsers for 3D modeling is still underestimated. The couple X3D-VR browser mostly was considered a system for visualizing 3D graphics on the Web which can allow real-time exploration. This impression is created mostly by e-learning vendors, which offer export of their models in X3D. The models created are static 3D worlds lacking dynamics and point-and-click capabilities. In the next sections, it is demonstrated that X3D and VR browsers can serve the more sophisticated tasks that are needed for 3D e-learning, i.e., query of the objects of the model to obtain thematic or spatial information [4].

3. X3D for Visualization and Interaction

As indicated above, the X3D document can be created either as a simple document for visualization and navigation only or as dynamic enabled document. In the first case, only the functionality of VR browsers, i.e., fly-over, walk-trough, pan, zoom can be employed. In terms of e-learning, simple X3D documents are applicable only for end visualization, i.e., no further information is to be provided. This type of virtual reality can be employed as a useful tool for distance learning [12].

The second type extends the ability to interact with the model almost unlimitedly. For example, each object in the current X3D document can be a clickable object invoking Java applets, CGI or Java scripts. Consequently, a new query to the database (on the server) or query of the X3D document arrived (on the client station) could be the next action. The new query could result again in a complex X3D document.

One of the most interesting issues for e-learning applications is the dynamic composition of a complex X3D document. The first basic operation is the identification of a certain object. As was mentioned before, the VR browser is not a complete GUI, e.g., point-and-click operation is not a responsibility of the browser. The browser reacts on user actions (other than navigation) only if they are initially and explicitly described in the X3D document. A particular sensor has to be attached to a particular object before the user is able to interact with that object.

The next step is the composition of the response. What does the user want to achieve selecting this object: text, graphics, image, and spatial analysis, and attribute information, data about the selected object or about other objects? In this approach, the decision on the type of sensor, the target object and the resulting event (CGI script or Javascript, or appropriate X3D nodes, or files on remote servers), has to be taken by the CGI script during the dynamic creation of the document [3, 10].

So far, only a user action has been considered as a possible input event to initiate an action. As was mentioned at the beginning, X3D is capable of sensing two other types of events: 1) dynamic interactions among objects and 2) time related changes. For example, a collision between two moving objects, a collapse of a building after a certain period of time or due to a contact with another object (e.g., plane), a crash of a plane if touches the ground, etc. Apparently, X3D has the potential to describe complicated static and dynamic spatial interrelations. The dynamic creation of such complex X3D documents, however, is not an easy task.

To avoid or reduce the undesirable effects of CGI scripting and facilitate management of dynamic interactions, the system can store appropriate supplementary information about behavior of objects in the database [7]. The behavior defines dynamic changes and interactions related to characteristics of objects such as shape, position, color, *etc*. However, behavior can be extended to comprise changes and interactions in the virtual world. Thus, a variety of parameters, scripts, small X3D files, animations, *etc.* per object that facilitate and simplify the work of CGI script can be captured in the database. The result is a possibility of CGI scripts standardization, which consequently decreases their number and reduces their size. Large worlds (i.e., long X3D files) can be partitioned into several smaller ones by assigning behavior to specific objects (doors, windows, *etc.*). The world can be reconstructed afterwards on user request as only one script is sufficient to deliver the entire file.

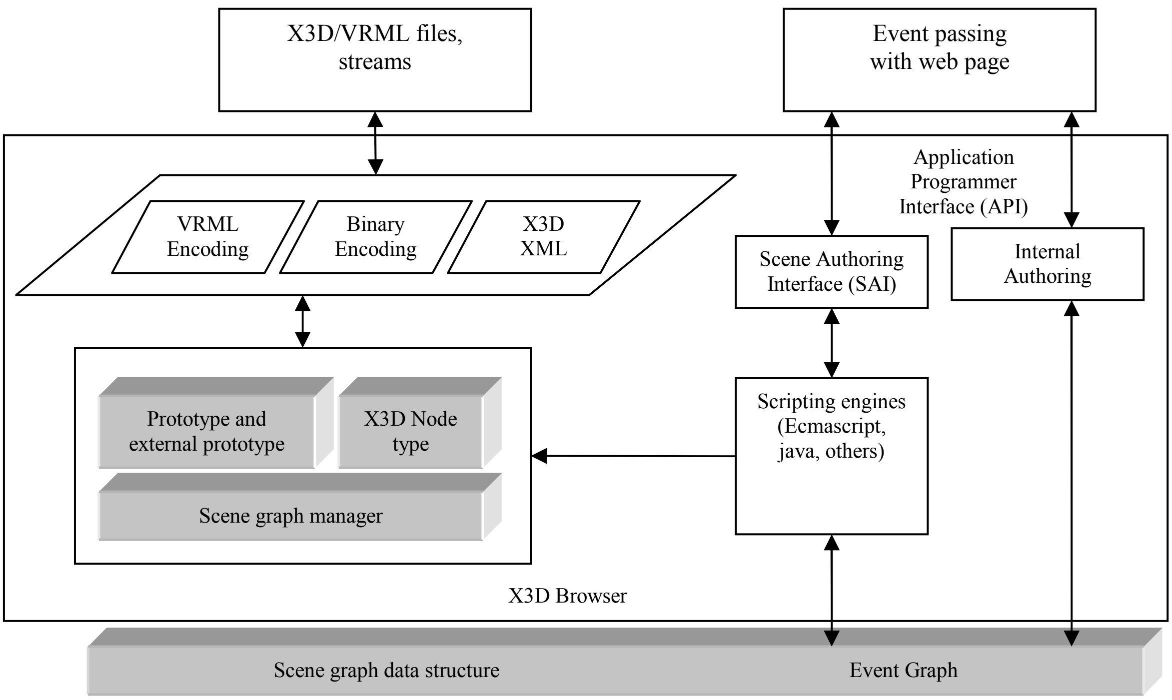


Figure 2. X3D system architecture.

4. Virtual Reality for e-Learning

The main goal of an educational virtual laboratory or class is to provide all the simulations, tools, applications and conditions necessary, which will constitute an efficient space where experimentation, communication and collaboration can be used for the maintenance and exchange of rich knowledge. Thus, the virtual environment that will host the laboratories, trying to simulate the learning process from its very beginning until its completion, should, first of all, include all the necessary functionality to its users so as to simulate the real processes as more realistic as possible [5, 11].

The virtual laboratories comprise virtual worlds where users are represented by 3D human with the ability to navigate in the environment, conduct experiments by interacting with the simulated equipment and collaborate by interacting with the other participants. Therefore, in a virtual laboratory where chemistry is selected, for example as the application field, the system will be provided the learners will have the ability to perform experiments according to the selected syllabus.

For the achievement of the purpose that a platform like this one could have, the functionality that will be provided by the Virtual Laboratory can vary in respect to the kind of the laboratory that will be simulated. However, in all cases the platform should support the following:

- Creation of Virtual Laboratories, where the placement and manipulation of objects that will be used to the experiments will be possible.
- Representation of the users both teacher and learners.
- Creation of dynamic characteristics attributes to the objects as color, lighting, *etc.*
- Definition of the possible ways of communication.

The previous functionalities can supply a wide range of the requirements that the learning process could have in a real laboratory. Such an environment could support learning by experience even in cases that either the lack of resources for the creation of real laboratories or the deficiency of available spaces constrain the learning process. The benefits of such an approach are the following:

- Significantly reduced cost for the composition of a laboratory, as it only requires addition of the necessary software to the existing Informatics Laboratory.
- Mistakes of both teacher and learners cannot cause any problem for the lab or user.
- The interaction with the virtual environment can motive the users.
- This idea allows the simulation of laboratories that could only exist in computers and could not be realized in real conditions.

As extracted from the above, the first criterion for the design and the development of a virtual laboratory is the selection of the field that will be adopted for the simulation processes. This field will define the procedures that should be simulated as well as the learning process that will lead to the achievement of knowledge and experience. The next step is to provide to the end users all necessary services so as to reach a high sense of realism [5, 11].

5. Implementation of the Proposed Virtual Labs

In this section, implementation of two virtual labs is shown. The first one is a virtual chemistry lab while the second one is an English language educational lab.

5.1. Virtual Chemistry Lab

In this sub section an implementation of an on-line virtual chemistry lab is shown. This virtual lab is built to help a distance student to perform all chemical experiments via an E-leaning site. This site is built for serving a certain chemical lab syllabus.

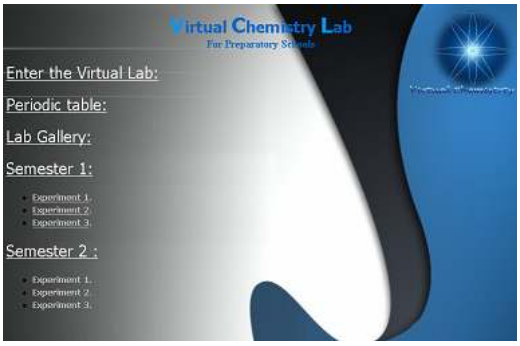


Figure 3. e-Learning site home page.

Our virtual chemistry lab site simply model or simulate a real chemistry lab using X3D language. This site is implemented based on the three tier architecture [11, 13]. The home page screen is shown in Figure 3. In this figure, there are five basic parts in the site, namely: a) the virtual lab model, b) periodic table link, c) lab gallery. d) semester 1 and 2 experiments. Each link will be described briefly in the following sub sections.

5.1.1. The Virtual Lab Model

When the user enters the lab he/she will find two basic view points, front and back view points. The view of the lab is very clear and simple as shown in Figure 4. It contains 2 cupboards for the chemical materials and equipments, and a centered table for performing the experiments. There are two different equipments on the table each links to a different experiment. At the back, there is a board holding the periodic table.

Figure 4. Virtual lab model.

5.1.2. Periodic Table Link

This link opens a page containing an image of the periodic table that contains the chemical elements symbols and elementary number. This page is shown in Figure 5.

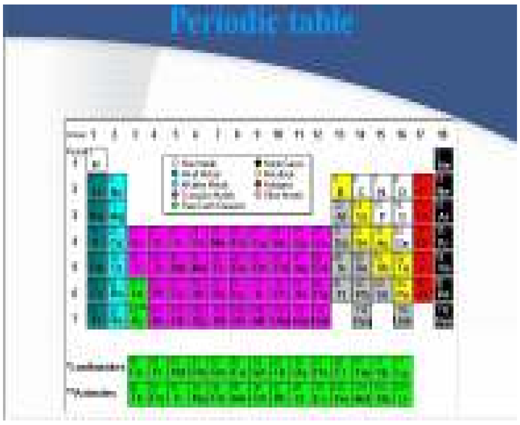


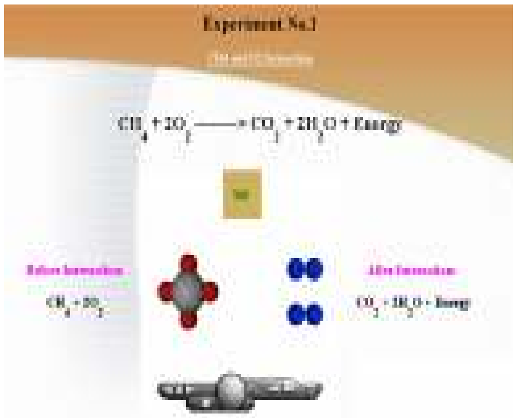
Figure 5. Periodic table link.

5.1.3. Typical Chemistry Experiments

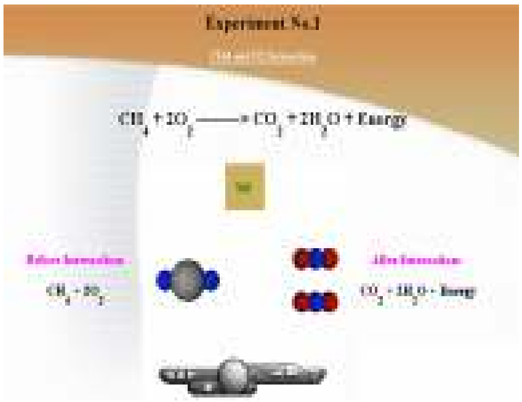
Experiments of a desired syllabus are ordered in the home page according to its order in the selected syllabus. For our example we select two experiments as a trail version of the site. Two experiments are included as examples.

In experiment one, we show the reaction between Methane with Oxygen gases showing their atoms reaction in a very amazing animation. As seen in Figure 6. (before and after the reaction), the reaction equation is shown above the 3D model of the experiment. Once the user clicks to start the reaction, the animation drives the reaction from Figure 6(a) to Figure 6(b). Also there are notes about the reaction symbols are displayed immediately.

In experiment two different elements interact separately with a third element, consequently a comparison between two reaction effects can be viewed by the student. The magnesium and carbon materials have different results when they interact with the oxygen gas. As described in the experiment two parts of magnesium and carbon are burnet and each is put in a graduated cylinder (with burning the materials, the reaction between them and the oxygen is happened).



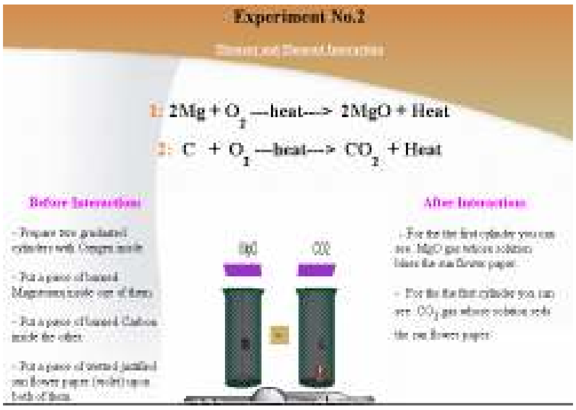
a. Before reaction.



b. After reaction.

Figure 6. Experiment one.

The results of the reaction are the oxides of each of them. The magnesium oxide solution has alkaline effect blues the sun violet paper, on the contrast, the carbon oxide solution has acidic effect reds the sun paper. As shown in the experiment model, it's very clear to see all the experiment materials and see the oxides gas which interact with the wetted sun papers to generate blue and red sun papers in amazing animation. Also the descriptions of the reaction are shown besides the model and the equations are displayed above it. In Figure 7(a) and Figure 7(b), the experiment is shown before and after the reaction respectively.



a. Before reaction.

b. After reaction.

Figure 7. Experiment two.

5.2. English Language Lab

In this sub section a virtual English language class room is implemented using X3D language. The home page of this system is shown in Figure 8. This page contains all English letters and a puzzle for some language exercises.

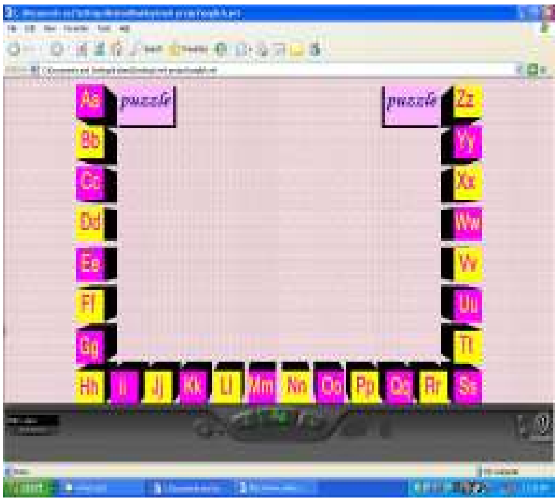
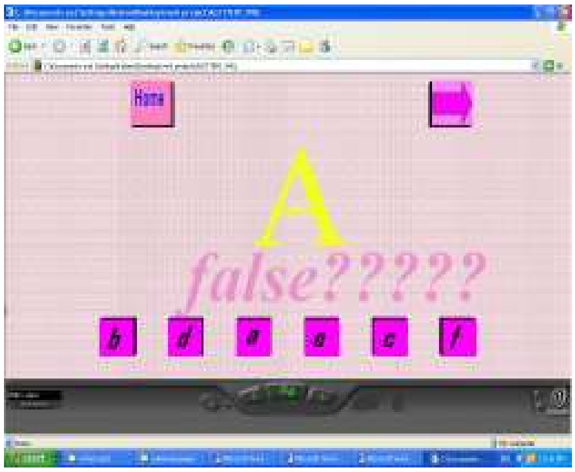
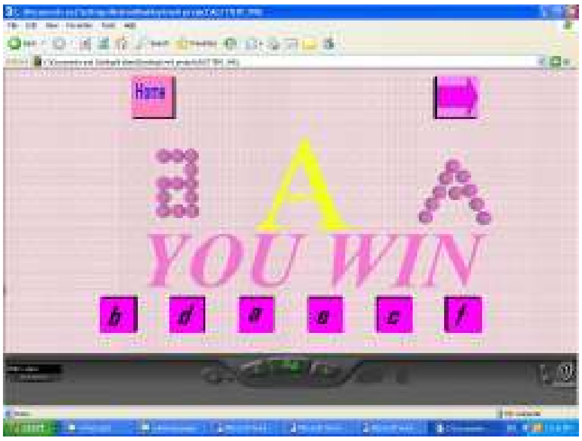


Figure 8. Educational English language system home page.

The implemented system contains two sub systems. The first one is used to distinguish between the capital letter and the small letters, if the user select any letter from the home page some exercises using this letter is shown in Figures 9 and 10.



a. False answer.



b. True answer.

Figure 9. Exercise to distinguish between capital letter and small letter.

The second subsystem contains a puzzle which has exercises for word. The user can open the puzzle link from the Home page, and then a panel of exercises for word is opened. The user can select one of the exercises where each one is supported with visual and audio aids to mange the use to hear the right pronounce for each word. An example can be shown in Figure 10.

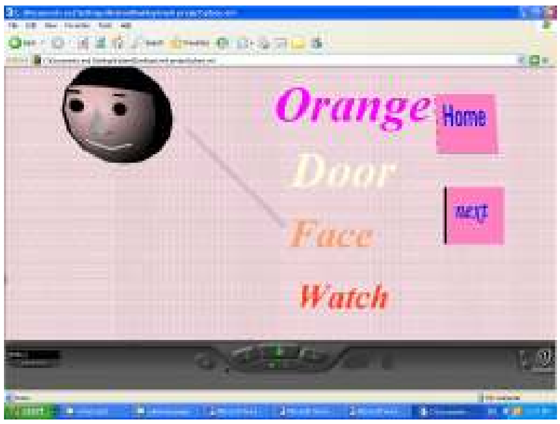


Figure 10. Exercise to select between many words (true answer).

6. Conclusions and Future Work

The role of conventional laboratories for training and understanding educational problems is presently being challenged. The advances made by virtual environments have led to some learning processes being replicated to varying degrees in the form of distance courses available through the Internet. Virtual Reality provides a friendly representation of the provided information, interaction with the system, which does not require advanced knowledge of the computers technology and reduced cost compared to other technologies. In this paper the ability of using virtual reality as a new technology to facilitate the distance application are demonstrated. This is achieved via developing two types of distance learning systems. The first one focuses on scientific labs applications which can facilitate the gained information of such subject in desktop virtual environmental systems. The second one focuses on foreign language labs applications which give many visual and audio aids besides the full manipulation ability for scene.

For future work or more complex design, the lab can contain 3D models of the equipments. Each object may be viewed separately in another world with brief description. Also if we could customize the experiments or exercises, where the user can gain more attention that may be implemented via asking the user to make any compound, and let the user pick the needed materials then prepare it for the desired experiment.

References

[1] Alexiou A., Bouras C., Giannaka E., Kapoulas V., Nani M., and Tsiatsos T., "Using VR Technology to Support e-Learning: The 3D Virtual Radiopharmacy Laboratory," *in Proceedings of 6th International Workshop on Multimedia Network Systems and Applications*, Japan, pp. 268-273, 2004.

[2] Barron T., "The Future of Digital Learning," *Computer Journal of e-learning*, vol. 1, no. 2, pp. 46-47, 2000.

[3] Bouras C. and Philopoulos A., "Distributed Virtual Reality Environments over Web for Distance Education," *in Proceedings of European Distance and e-Learning Network Conference*, Italy, pp. 481-484, 1998.

[4] Burdea G. and Coiffet P., *Virtual Reality Technology*, Press Wiley, 1994.

[5] Chittaro L. and Ranon R., "Web3D Technologies in Learning Education and Training: Motivations, Issues, Opportunities," Computer *Journal of ELSEVIER Computers and Education*, vol. 3, no. 49, pp. 3-18, 2007.

[6] Dimitropoulos K., Manitsaris A., and Mavridis I., "Building Virtual Reality Environments for Distance Education on the Web: A Case Study in Medical Education," *Computer Journal of International Journal of Social Sciences*, vol. 2 no. 1, pp. 62-70, 2007.

[7] Göschka K. and Riedling E., "Web Access to Interactive Database Training: New Approaches to Distance Laboratory Work at the Vienna University of Technology," *in Proceedings of the 15. IFIP World Computer Congress*, Austria, pp. 349-360, 1998.

[8] Kalogeropoulos N. and Karatzas X., "Real or Virtual Laboratory, The Case of Volumetric Analysis in Chemistry," *in Proceedings of Intra School Education on Information and Communication Technologies*, Thessaloniki, pp. 159-163, 2002.

[9] Kubo M., Tori R. and Kirner C, "Interaction in Collaborative Educational Virtual Environments," *Computer Journal in Cyberpsychology Behavior*, vol. 6, no. 4, pp. 399-407, 2002.

[10] ISO/IEC 19775:200x, Final Committee Draft "Extensible 3D", http://www.web3d.org, Last Visted 2010.

[11] Preis K., Bárdi I., Biró O., Hoschek R., and Mayr M., "A Virtual Electromagnetic Laboratory for the Classroom and the www," *Computer Journal of IEEE Transactions on Magnetics*, vol. 33, no. 2, pp. 1990-1993, 1997.

[12] Roche B. and Mangina E., "Agent-Based Framework for Intelligent Tutoring Systems within University College Dublin," *in Proceedings of the International Conference on Information Communication Technologies in Education*, Greece, pp. 179-186, 2003.

[13] Sin Neo K., Lin Q., and Gay R., "A Web-Based System for Interactive Visualization of Scientific Concepts," *in Proceedings of the ACM SIGGRAPH International Conference on Virtual Reality Continuum and its Applications in Industry*, USA, pp. 233-239, 2004.

Hatem Abdul-Kader received his BS and MSC both in electrical engineering from the Alexandria University, Faculty of Engineering, Egypt, in 1990 and 1995, respectively. He recived his PhD degree in electrical engineering also from Alexandria University, Faculty of Engineering, Egypt, in 2001 specializing in neural networks and its applications.