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The Effect of Controlled Adaptive Repetitions on Student Learning in 3D Virtual Learning Environments

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Article Info

Abstract

Research shows that cognitive aids such as audio, video and visual etc. can help reduce mental load on students when working in 3D virtual environments but at the same time it may hinder students' active exploration. Active exploration is necessary when the student perform the same experiment in physical world. The strategy of adaptive repetition is used as a control strategy to actively explore 3D virtual learning environments. However, this adaptation occurs automatically without allowing students to choose when to use the aid and what type aid to use. In this study, a controlled adaptive repetition strategy is proposed where the system facilitates students to repeat a task with a desired type of aid while working in 3D virtual learning environments. Experimental results shows that the proposed strategy is effective which enhances active exploration and students perform better in physical world.

Keywords: *: Virtual Reality, 3D virtual Chemistry Lab, 3D Adaptive Virtual Learning Environment, Controlled Adaptive.*

Introduction

Virtual Reality (VR) refers to computer technologies that use different types of softwares to create realistic images, sounds and other sensations to create an immersive atmosphere and simulate a user's physical presence in this environment [1]. VR is an emerging technology of keen interest in the field of education and research [2]. VR is a key research area in different domains such as medical, engineering, educational training and teaching. Researchers are working to use VR in education which allow users to accomplish their work in virtual laboratories. Researchers are investigating the use of VR to enhance education, such as virtual labs, for interactive learning experiences [3].

In natural sciences such as Chemistry, Physics and Biology, virtual laboratories can simulate real- world activities in an engaging and intuitive graphic environment to assist students to obtain new knowledge and skills through learning by doing [4]. Virtual Learning Environment (VLE) is a combination of teaching and learning technique proposed to develop a student's learning skills through computers and the Internet in the learning process [5]. VLE is a platform developed to support teaching and learning process through the internet. This overcomes the restriction of traditional face-to-face learning and ensures that teaching is neither limited to physical location nor time [6]. The usage of 3D virtual learning environments has many advantages. Environment that change according to user needs and the events that they executes in the environment [7]. It measure learning skill of a learner in 3D-VLEs and practice it an adaptation standard for presenting adapted teaching stuff to different learners [8]. Zhu et al. [9] developed adaptive learning management system. The results shows that learners are satisfied and considered the implementation of adaptive instructional strategies useful for adaptive education. The major difficulty is to develop four versions of the same course to meet the personalization of learning process. Moodle LMS is an open source and online application which offers wide range of options for a teacher to plan and implement adaptivity in the process of an e-learning course design. It is complex and require more time for implementation as compared to traditional e-learning [10]. For simulating chemistry experiments, different virtual chemistry labs have been proposed in the past. The Virtual Chemical Laboratory Crocodile Clips Chemistry (VCLCCC) [11] is a sophisticated, easy and interactive simulation platform. The proposed system allows limited interaction facilities with chemicals. Nais et al. [12] created a virtual chemistry lab, Each experiment was equipped with an experimentation monitor that includes objectives, gears, resources, and techniques. This is an online platform having limited number of interaction tools. Ali et al. [13] developed a Multimodal Virtual Chemistry Lab (MVCL) to provide detailed information about the physical and chemical properties of chemical items while simulating the chemical experiment in a VR. This framework focus on the physical and chemical properties of chemical items.

Cognitive aids in 3D Virtual Learning Environments (3D-VLEs) help students by providing by easy-to-follow guidance for spatial tasks which reduces mental load on learner [14-17]. However they may effect active exploration wchich affect students performence in the physical envirnment [17, 18]. controlled use of aids when combinely used with semenatic aids encourages active exploration in 3D-VLEs and can improve real world task performence[19]. Alam et al. [20,21] used adaptive repetition as a control strategy to inquire about the 3D virtual learning environment. They only used visual, audio and textual information for simulating the chemical experiment**.** The adaptation occurs automatically without allowing students to choose when to use the aid and what type aid to use. In this study, a controlled adaptive repetition strategy is proposed where the system facilitates students to repeat a task with a desired type of aid while working in 3D virtual learning environments. Experimental results shows that the proposed strategy is effective which enhances active exploration and students perform better in physical world when these aids are not available.

1. CONTROLLED ADAPTIVE REPETITION FRAMEWORK

In this research work we developed a virtual chemistry lab named Controlled Adaptive Repetition Framework for the implementation of our research strategy (The effect of controlled adaptive repetition on student learning). In the proposed system the adaptation is based on the choice of the students. The system provides three types of cognitive aids (graphical, textual and video) for learning. Here the student can repeat the experiment with same aid or can use different one.

2.1 Research Hypothesis

The proposed controlled adaptive repetition framework is based on the following hypothesis.

H: Controlled adaptive repetition with student preferences enhance students learning in 3D virtual learning environments.

2.2 System Architecture

The overall architectue of the Controlled Adaptive Repetition Framework (CARF) is shwon in Figure 1. The architecture consists of many modules such as User interaction, Cognitive Aids (Video, textual and graphical), experiment procedure module, and Experiment Simulation module. These system modules are explained below.

2.2.1 User interaction

This link user with the Controlled Adaptive Repetition Framework (CARF) and enable the user able to move freely inside the VE and manipulate diffrent virtual substances.

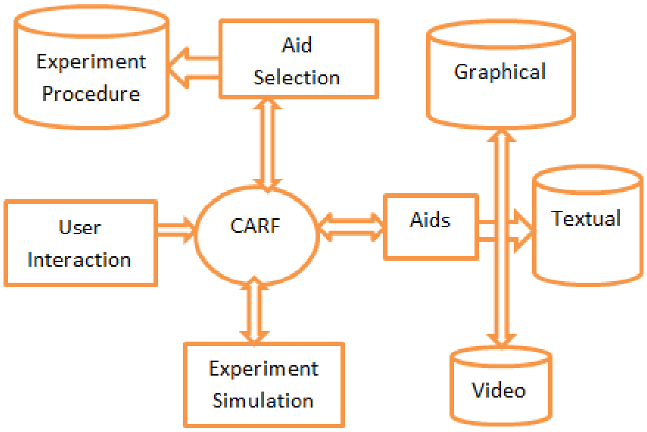

Figure 1: System architecture

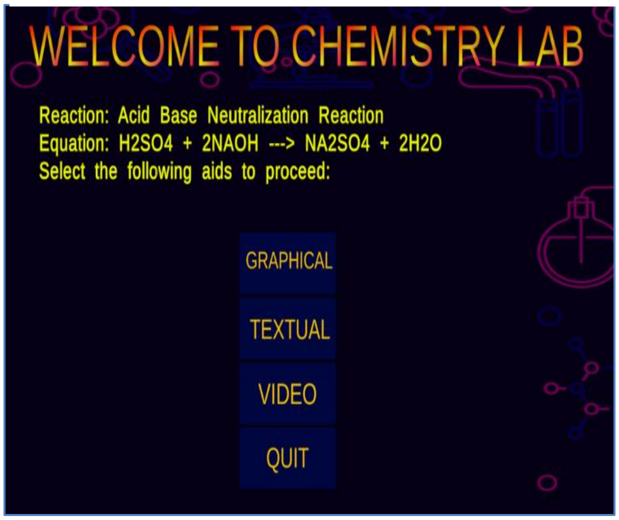

Fig. 2. Types of Cognitive Aids

2.2.2 Cognitive aids

The proposed system consists of the following aids as dipicted in Figure 2:

Graphical aids: - Pointers are used as graphical aids for guiding users in the proposed system.

Textual aids:- Textual aids consist of brief information related to the chemical reactions in the VLE. This aid show materials and tools used in the chemical process and also show step by step textual guidance.

Video aids:- Video aids consists of combination of sound and picture which provide detail information about the practical and procedure.

Aid selection module enable student to select any type of aid to perform or repeat the experiment.

2.2.3 Experiment Simulation

This section shows the simulation of an experiment in a virtual environment. During simulation, an equation of the resultant chemicals procedure is shown on the virtual screen of the CARF as shown in Figure 3. The step by step procedure of experiment is displayed and all the chemicals required for the experimrnt appears in the virtual lab.The student is guided through audio, video and textual aids to perform the steps of experiment in correct order.

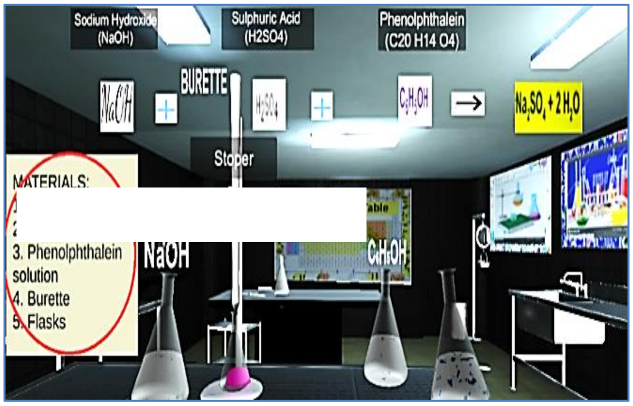

Fig. 3 Experiment simulation

2. EXPERIMENTATION

This section discuss the implementation, experimentation and assessment of the Controlled Adaptive Repetition Framework.

3.1 Implementation

For experimental purposes, the proposed startegy CARF was implemented using Unity 3D for front end and C Sharp language for back end. The Hardware used was Dell Corei3 system having specification 2.8GHz processor, 8GB RAM. The keyboard and mouse were used for interaction with the simulated environment. Similarly, another system of the same configuration was for the comparison with the proposed system.

3.2 Experimental Protocol

For experimental purposes, forty students including 30 male and 10 female were selected from of different collges to participat in the evaluations process of the proposed system. They were intermediate level students. Students were briefed how to select and manipulate objects in the VE to execute the stepsof an experiments. The students performed the experiment "standardization of sodium hydroxide solution by standard solution of oxalic acid" using the previous system while they performed another similar experiment "standardization of sodium hydroxide solution by standard solution of Sulphuric acid" on Controlled Adaptive Repetition Framework in VE. After using the previous system, students appeared in test T1 of 20 marks. Similarly, student were ask to appear in test T2 after using the proposed system. Experiments were accomplished in real time and the whole experimentation process took 100 minutes. After experiments, students filled questionnaire.

3. EXPERIMENTAL RESULTS AND ANALYSIS

4.1 Students Learning

Both systems were used to check the performance of the learners. Test one (T1) represents the marks of previous system while test two (T2) shows proposed system marks. Results show that 78% students got higher marks, 15% show equal results while rest of 7% shows negative result on the new system. We compared the Mean and STD values test marks of learners on both system. Mean and STD value for the previous system is 12.92 and 3.48. Similarly, Mean and STD value for the new system is 15.27 and 2.96. on average, students showed an improvement of 2.35 points using CARF. Similarly, STD value alsoreduced from 3.48 to 2.96 which also show an improvement in terms of learning efficiency. Mean and Standard Deviation (STD) value for the new system CARF revealed that learner shows better result as compared to the old one. Figure 4 and Figure 5 summarises these results.

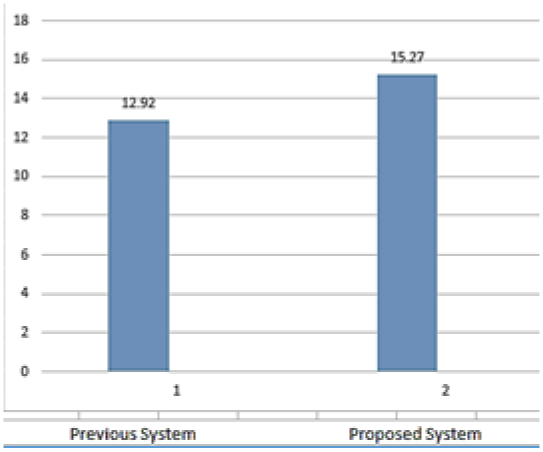

Fig.4. Mean of students marks on both system

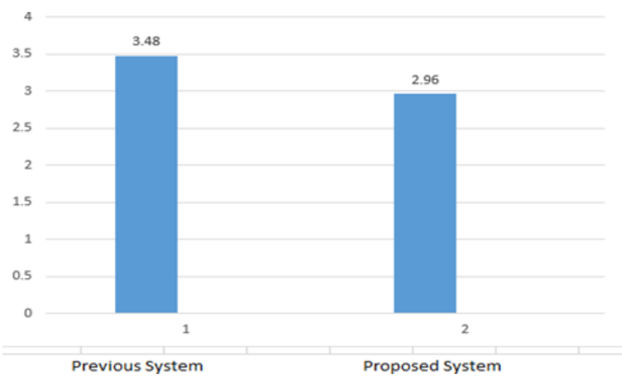

Fig. 5. STD of student's marks on both system

4.2 Subjective Evaluation

In order to evaluate the new system CARF subjectively, questionnaires were distributed amongst the 40 students. As displayed in table 1, the questionnaire comprises of five questions related to the efficiency of CARF. Figure 6 shows students answers for Q1, Q2 and Q3 on scale of 5 points. For Q4 and Q5, learners were simply questioned to provide their opinions about both systems.

Table 1 Subjective questionnaire

S.No	Questions
1	Do you think providing cognitive aid according to student preference is suitable option?
2	The proposed system helps the student to perform the experiment in physical lab without any assistance.
3	Proposed system provide the environment to perform the experiment in the same way as they do in the actual lab while previous system display module based on student performance.
4	Which system enhance active Exploration?
5	Which framework for 3D Adaptive-VLEs do you prefer?

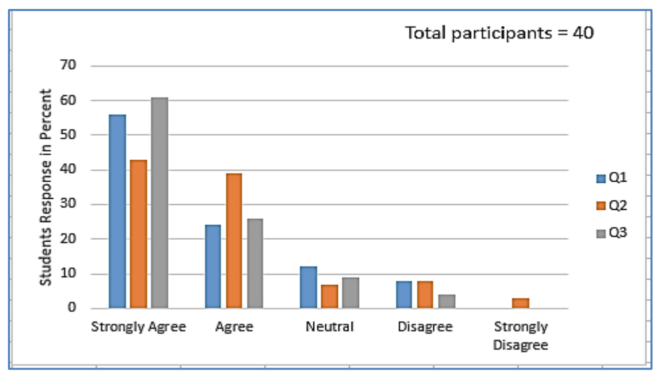

Fig.6. Students responses for Q1, Q2 and Q3.

Students answer for Q1, 56% students marked it strongly agree, 24% marked agree, 12% replies were neutral and the rest 8% marked it disagree. For Q2, 43% learners marked strongly agree, 39% pupils were agree, 7% were neutral, 8% marked disagree and 3% were strongly disagree. Similarly, for Q3, 61% students were strongly agree, 26% were marked agree, 9% were neutral and the rest 4% were disagree. From students' replies, it was perceived that for Q4, 45% marked the previous system while 55% marked the CARF. Similarly with answer to Q5, 78% learners wishes to use the CARF for learning process while 22% wants to use the previous system.

Questionnaire also contain question to compare some attribute of the old system and the new system CARF. The attributes of the system are given in table 2 and students' feedback is summarized ais shown in Figure 7. Students feedback for for A1 about system attributes, 36% marked the previous system and 64% preferred the proposed system CARF. For A2, 31% were in favor of previous system while 69% selected the CARF. Similarly, for A3, 19% marked the previous system and 81% showed positive answer for the CARF System. For A4, the response was 23% and 77% for the previous system and CARF, respondingly. Similarly, for A5, 44% were agreed on previous system and 56% marked the proposed system CARF.

Table 2 System attributes.

S.No	System Attributes
1	Over all Simplicity of the system
2	Ease to learn to use the system
3	Motivation towards learning
4	Student friendly/ Interactive
5	Over all, I am satisfied with system

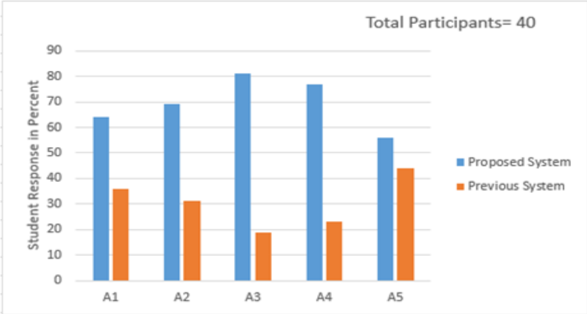

Fig. 7. Students feedback regarding system attribute.

4.3 System Usability Scale

System Usability Scale (SUS) is a well- Known , speedy and effective tool for determining the usability of the system. It shows detailed information about the system interfaces and their usage. SUS comprises of a 10 item questionnaire with five responses options for respondents; from Strong agree to Strong Disagree [22].

4.3.1 System usability scale calculating score

Step1: Convert the scale each of the 10 questions. Strongly disagree represents1 point, disagree 2 points, neutral 3 points, agree 4 points and strongly agree 5 points.
Step2: X= sum of all the points for all odd number questions. Y= sum of the points for all even numbered questions.
Step3: Calculate X0= X-5, Y0= 25-Y, SUS Score= (X0+Y0)*2.5
SUS graph value of the previous system is 71 while for proposed system CARF, it is 77 which show that majority of the students were willing to use the new system CARF.

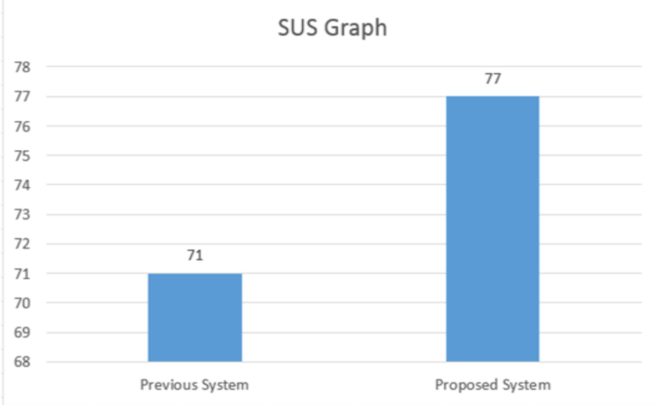

Fig.8. SUS Graph value of previous and proposed system.

4. TESTING THE HYPOTHESIS

The outcomes of students learning, subjective evaluation and standard usability scale (SUS) (Figure 8) demonstrated that students can effectively simulate their experiments by CARF in 3D virtual learning envirnment. Arithmetic mean and standard deviation of the students using CARF is 15.27 and 2.96 while for the old system it is 12.92 and 3.48. SUS value for the previous system is 71 and 77 for the new system which reveal that proposed system is better than the privious one in terms of usability. From experimenal analysis the hypothesis of the study “controlled adaptive repetition with student preference enhances student learning in 3D VLEs” become true. Hence we can say that the proposed system efficient and motivate students toward learning.

5. CONCLUSION

In this study we proposed a framework based on the concept of of Controlled Adaptive Repetitions strategy for adaptive 3D VLEs. The proposed system (CARF) provide three types of cognitive aid (Graphical, Textual and Video) and students have given choice to use which they want to use to perform the experiment. They can repeat the experiment with the same aid or can use different aid in repitition. We carefully conducted several surveys/tests to find factors that can improve students learning in 3D-VLEs. Questionnaires were distributed among students of different colleges and data were collected. Solutions were planned, simulated and tried in real time atmosphere to calculate their usefulness in 3D-VLEs. The result of the work is an effective student friendly framework CARF. CARF provides maximum number of cognitive aids according to student preference.that increases the learning skills of a student in adaptive 3D-VLEs. Comparing with the previous system, CARF is more efficient, interactive and flexible.

The first limitation of the study is, that we only implemented two reactions of first year chemistry book. Other reactions shall also be considered for implementation. Secondly, CARF is desktop based and offline. One of our future work is to implement all the many reactions of first year chemistry book in the same environment. The second future work is to make a dynamic and online interactive CARF where the learner will be capable to use CARF online and will be helpful in distance learning education.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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