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The Effect of Task Distribution Model on Student Learning and Performance in Collaborative Virtual Environment

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Abstract: In this paper, we used task distribution framework in a typical educational environment to enhance the learning capability and user performance of collaborative users. We emphasize on the design of Collaborative Virtual Learning Laboratory. As a case study, we describe how interactive 3D virtual learning laboratory can be used to understand the laboratory experiments in a collaborative mode while providing the learners with the ability to control these laboratory animations in real time interaction and enhance their learning capability and performance based on task distribution model. We also stress the need for an educational Collaborated Virtual Learning Environment (CVLE) to be more convenient and pleasurable, which will enhance its usability and flexibility in various situations. We conducted experiments in virtual chemistry laboratory on different college students to check the learning capability and performance of the students based on task distribution model in CVLE. We reported the results of a precise experiment containing of 22 virtual teams of 44 entities.

Keywords: - Virtual Reality, Collaborative Virtual Environment; E-Learning, Interaction; Real-time Collaboration, Awareness**.**

1. INTRODUCTION

In the last two decades, the world has witnessed a radical progress in the field of e-learning as we have transitioned from a computer based training (CBT) using a single computer to Collaborative Virtual Environment (CVE) based training using large number of interconnected computers with varying degrees of Human-Computer Interaction (HCI) capabilities across the globe. At the heart of an Interactive Collaborative Virtual E-learning Environment (ICVEE) that promotes higher order learning in the true sense, lies the ability of the virtual environment to provide an educational experience where information creation and information in action link pedagogical and intellectual presence based on the community of the enquiry model (Garrison *et al.* 2001).

Most of the commercial e-learning systems today enable synchronous co-operative learning e.g. sharing documents and online meetings (Bouras *et al.* 2005), rather than asynchronous collaborative learning. Virtual multi user collaboration tools often fall into three categories as described by (Spellman *et al.* 1997), collaborative learning is chatty, formless, iterative and an active process well suitable for tasks where students are required to mutually design, create or evaluate something (Alexander 2006).

Virtual environments for multi users have emerged among the students as a means of confidence and competence (Peck *et al.* 2010). Special care needs to be taken while designing an interactive e-learning CVE to employ the right model for the right kind of audience. Detailed comparison of computer supported collaborative learning (CSCL's) and computer supported cooperative work (CSCW's) characteristics have been mentioned by (Alexander 2006). It must be noted that learning techniques can have different impacts on the students with different learning styles as suggested by (Lee *et al.* 2010). "Learning by doing" concept is not new; however, permitting the student to learn by doing within the classroom environment going away from traditional methods (Bruner 1990). So, in this way, laboratory components for education play a vital role to make students gain experience. Particularly, in the field of chemistry which is totally practical branch of science, the importance of laboratory applications is clearly understood. To conduct chemistry lab experiments, students become active in their learning by seeing, observing and doing. So in this way permanent learning is achievable by doing such kinds of application (Temel *et al.* 2000) (Ali *et al.* 2015).

Due to unavailability of laboratories at colleges and schools level or inadequate apparatuses in laboratories, hands on experiments are rarely performed in colleges and schools in developing countries. However, such experiments can be virtually done as a result of new advances in field of Information Technology.

In section 2, related works have been discussed. In Section 3 the task distribution model is presented. In Section 4 the experimentation and analysis based on task distribution model to check performance and learning capability of the students are shown. Conclusion and future work are given in section 5.

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2. RELATED WORK

In the arena of collaborative virtual environments for education, several systems with varying degrees of sophistication and complexity have been proposed and realized to some extent. However the e-learning community is still in nascent stages as far as realizing the framework and implementation of a real-time ICVEE, which is adaptable across the e-learning community is concerned (Bijlani *et al.* 2011). (Limniou *et al.* 2008) Describes the fully immersive virtual reality environment based learning platform for chemistry education. However the limited scope as well as high cost involved in installation of such systems may be a limiting factor to its wide acceptance. (Kurillo *et al.* 2008) presents a model for immersive virtual environment intended for remote collaboration and training of physical activities, but suffers from the same drawbacks, as of (Limniou *et al.* 2008). (Monahan *et al.* 2008) describes a web-based collaborative e-learning environment with virtual reality. There is no provision for asynchronous learning. (Shi *et al.* 2010) tries to narrow the gap between the teacher's experience in traditional classroom education and Tele-education, by means of combining these two detached education environments together.

In the field of chemistry education to conduct experiments, Virtual lab (VLab) is used. VLab is a web based 2D collaborative environment. In VLab system, two students select chemicals and apparatus's collaboratively via chat. The VLab system improves the learning capability of the students but due to 2D nature of the environment it is less realistic (Tsovaltzi *et al.* 2010). A 3D collaborative virtual chemistry laboratory has been developed in Charles Sturt University. In this laboratory, the students collect the apparatus and chemicals and discuss with each other to know the procedure to conduct the experiment in real laboratory. In this lab no simulation are given for chemical reaction. This 3D environment is useful only for students to train them for the real laboratory (Dalgarno *et al.* 2012).

Oxford University in England developed an online virtual chemistry laboratory for their undergraduate students. In this laboratory, several experimentations are given in video clips. In this lab students are trained based on video clips to conduct the experiments easily in real lab. This lab is appropriate for undergraduate students but it is less interactive due to clips mechanism for learning (Mark 2015). The iVirtualWorld is another web-based environment which contains 3D objects selected from 2D menu. Mouse is used for interaction with objects. It also provides 2D graphical user interface in which the selected objects characteristics are set. Due to 2D menu objects selection approach and setting their properties, the environment is less realistic and hence becomes difficult to achieve more immersion in the environment for user (Zhong *et al.* 2014).

To best train students and to improve their performance and learning capability, a 3D virtual collaborative labs simulation environment is developed in this paper based on task distribution strategy, called collaborative virtual learning environment (CVLE). Up to the authors' knowledge no one has discussed the strategy to conduct chemistry lab experiments collaboratively in a virtual environment using task distribution strategies. Our CVLE is interactive in which several awareness modalities i.e. audio and visual are used for communication, which also increases user performance and co-presence in the environment. The chemistry lab experiment will be conducted collaboratively in this paper using task distribution strategy to check user performance and learning level of the students.

3. TASK DISTRIBUTION MODEL

A CVE consists of Tasks, Objects and Users. Task is further divided into $Task_1$, $Task_2$, $Task_3$....$Task_i$ and objects set consists of $Object_1$, $Object_2$, $Object_3$..$Object_J$. Users consist of $User_1$, $User_2$, $User_3$...$User_m$.

To describe task distribution model, consider the scenario of a CVE where in first phase the assembly of multiple fundamental parts of a product is carried out and then they are combined to obtain the complete product in the second phase. This task can be realized in two ways. Firstly the users making a single group will do the assembly of constituent parts successively i.e. task T is completed by completing subtasks $Task_1$, $Task_2$....$Task_i$ in the given order. Secondly when many groups of users are involved for task execution, then specific task is assigned to each and every user of the group. In both cases the first step is the task selection as shown in **(Fig.1)**. The next step is to determine how the group members will realize the task? The task distribution model suggests two ways in this situation.

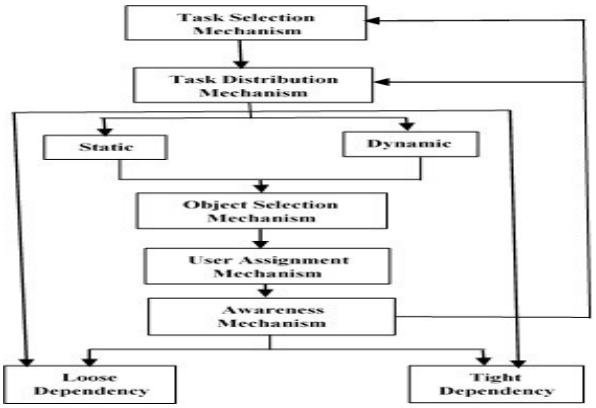


Fig. 1 Task Distribution Model

a) **Static Task Distribution Mechanism: -** As he task will be performed collaboratively, so multiple users will be involved for task execution. In static task distribution mechanism the users of each group know in advance that which task or subtasks, he or she will going to perform in CVLE. So each user will select his/her specified task. Awareness and communication among group users throughout task implementation depends on task/subtasks dependency. For loosely coupled tasks, dependency is less, so fewer communications will be required. Similarly, for tightly coupled tasks frequent communication is desirable.

b) ***Dynamic Task Distribution mechanism*: -** In this type of task distribution, the task or subtasks execution are not assigned to the users of the group in advance. For $task_1$ execution, all users will be actively involved to complete $Task_1$. When $Task_1$ is completed then via communication modalities all users are informed to start $Task_2$, after completion of $Task_2$, $Task_3$, $Task_4$ $Task_i$ will be performed in the same manners. This type of task distribution mechanism is called dynamic task distribution mechanism. The same dynamic task distribution mechanism in CVLE will be followed for subtasks, if the subtasks further consist of multiple objects. For dynamic task distribution high communication and strong awareness are required.

For example when the user selects the experiment of standardization of sodium hydroxide by oxalic acid, which description is the following:

Weigh out accurately of oxalic acid in a weighing bottle. Using a beaker, dissolve the acid in distilled water, then transfer the solution to volumetric flask. By pipette take alkali solution from beaker, run it into a conical flask, add two or three drops of phenolphthalein solution. Then run in 1 cm^3 at a time, shaking after each addition until the solution becomes colorless. The eq.1 will be displayed.

$2NaOH + H_2C_2O_4 \longrightarrow Na_2C_2O_4 + 2H_2O$ Eq. 1

To perform the same procedure in chemistry interactive virtual lab to obtain eq.1 reaction, the task distribution will be the following:

Static task distribution for chemistry Lab Experiments:- To conduct this experiment in chemistry 3D interactive virtual laboratory collaboratively by 2 users, the static task distribution will be the following: Oxalic acid solution preparation is assigned to user1; Phenolphthalein and sodium hydroxide solution preparation are assigned to user2 in advance.

For oxalic acid solution preparation, the user1 brings $C_2H_2O_4$ bottle from shelf to the table, removes head then picks china dish and puts it on scalar for calculating its weight. With the help of teaspoon, takes a spoon of $C_2H_2O_4$ and takes it to the scalar and pours it in china dish in a small amount. Now, takes the china dish from scalar and puts it in water beaker. The Oxalic solution is displayed in CVLE in the form of label and also on the virtual board. Further, the user1 takes solution of oxalic acid with the help of pipette and puts it in volumetric conical flask. All the process activities will be told to user1 in advance for executing their specified tasks and will be communicated to user2.

User2 assigned task is to bring NaOH and Phenolphthalein bottles to table, remove heads from them, bring two water beakers to the table, with the help of spoon take NaOH and Phenolphthalein chemical from bottles and puts them in separate water bottles. Next, with the help of pipette, takes solution from water beaker of NaOH mixture and Phenolphthalein and puts them in conical flask. When all three solutions are put in the volumetric conical flask, eq. 1 is displayed on user screen and the experiment completed collaboratively and both users will be informed via communication /awareness modalities.

Dynamic Task Distribution for chemistry lab experiment: - To conduct this experiment in chemistry 3D interactive virtual laboratory collaboratively by 2 users, the dynamic task distribution will be the following:

First both users will prepare oxalic acid solution, then Phenolphthalein and last sodium hydroxide collaboratively. Then will combine three solutions to obtain resultant solution as described below.

For oxalic acid solution preparation, both users i.e. user1 and user2 go for $C_2H_2O_4$ bottle to bring it onto the experimental table from the shelf. The one reached first will inform the second that you should bring water bottle to the table, then head of bottle will be removed by any one user which is free and the other when becomes free will take the china dish and puts it on scalar for calculating its weight. The free user will take teaspoon and for taking up chemical from $C_2H_2O_4$ and will pour it in china dish in a specified amount and then will take the china dish from scalar by the free user and will put the china dish in water beaker and Oxalic solution will be displayed in CVLE in the form of label and also on the virtual board. The collaborator when becomes free will go for picking the pipette and will take solution from the beaker for putting it in the conical volumetric flask on the table. Both users will use awareness modalities to inform his/her collaborator. Similarly the same procedure will be taken for NaOH and Phenolphthalein solutions preparation.

4. EXPERIMENTATION AND ASSESSMENT

Environment

To examine the effect of static and dynamic task distribution mechanism as shown in the proposed model in **(Fig.1),** to check students' learning, a large scale

CVLE is developed as shown in **(Fig. 2).** The environment provides 3D interaction interface which facilitates the users to sense more involvement in a 3D environment. It enables the users through 3D interaction to simulate their chemistry experiments easily and to take more interest in chemistry practical learning. The inside set-up of the CVLE is shown in **(Fig.2)**. Chemicals, equipment, experimental table and other required apparatus are visualized inside the lab. To make the interaction easy and easily identify the chemical, all chemicals are placed in cupboard and others apparatus and glassware like digital balance scalar, rack for test tubes, stand, spirit lamp and pipette are placed on experimental table as shown in **(Fig. 2).**

In CVLE, a virtual board is used which shows information about apparatus, chemicals and equation related to the experiments. If a subject performs and simulates the experiment successfully according to the procedure then a message will be displayed to both collaborative users on virtual board containing that "you successfully completed the experiment".



Fig. 2 The inside scenario of CVLE

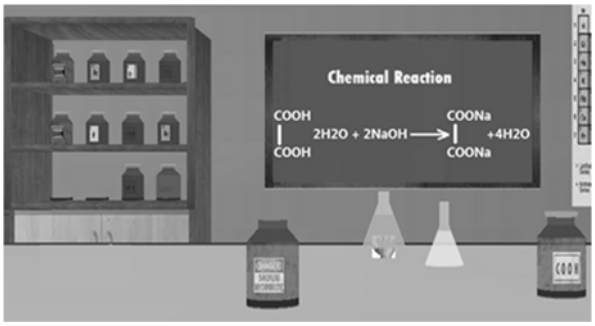


Fig. 3 Objects Simulation Scenario of CVLE

Experimental Structure

To conduct the chemistry lab experiment, CVLE is developed and installed on two laptops having core i5 processor, 4GB RAM and NVIDIA graphic cards. The environment is replicated and client server based. Both the stations are connected via un-shield twisted pair cables as shown in **(Fig.4)**. WIIMOTE controller is used for interaction. As the environment is collaborative, audio and textual modalities are used for information sharing. It is developed in C++ and OpenGL Library and for audio; SoundTap Audio Streaming Recorder software is used.

In order to evaluate the system and examine the task distribution effect with awareness modalities on user learning in CVLE, we conducted virtual chemistry lab experiment on different users. Forty four (44) students divided to 22 groups (each of two students) willingly participated. Participant ages were from 16 to 20 years. A short briefing was given to the group members about the experiment procedure. A pre-trial was conducted so that the group members become familiar with scenario, objects and awareness modalities in the system. All the forty four group members performed the experiment under the two conditions, i.e. C1 (Dynamic task distribution) and C2 (Static task distribution). When the scenario was loaded the time counter started and ended when the task was completed. The task completion time for each experiment was noted. After the experiment a learning based questionnaire was given to each participant to take a subjective feedback in order to calculate the learning level of the subjects.

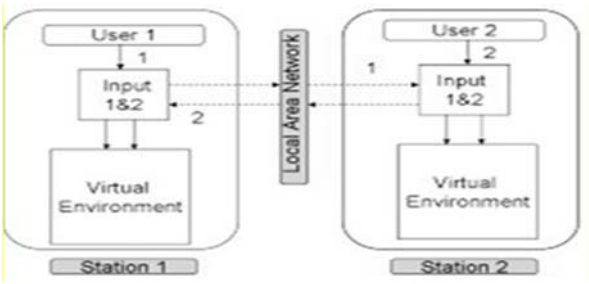


Fig. 4 Experimental Setup Procedure

Task

At start, user selects the experiment from the experiments' list that which experiment he/she will perform. After selection of an experiment user can select the objects that which chemicals and apparatus will be used for the selected experiment to perform it. Every experiment contains its own step by step procedure. The objects involved for conducting the experiment are summarized as follows.

To transfer liquid, pipette is used. To take the solid chemicals from bottles and pour it into china dish the teaspoon is used. The balance/scalar is used for calculating china dish weight before and after chemical is put in it. China dish, containing chemicals, are transferred into the beaker for chemical reaction. Similarly beakers contain different chemicals solutions and via pipette these solution are transferred to resultant solution beaker for final reaction as shown in **(Fig.2)**. When the experiment is completed successfully, then user obtains the simulation of an experiment and the

chemical equation of the experiment is displayed on the virtual board. For example, standardization of sodium hydroxide by oxalic acid the following equation is displayed as shown in **(Fig. 3).**

In the below subsections task completion time and errors made in task execution are analyzed for checking user performance level in CVLE based on task distribution mechanism. Feedback taken from the users via survey based questionnaire are examined and discussed.

Analysis/ Results

Task Accomplishment Time

For task accomplishment the ANOVA (F (1, 43) = 4.425, p < 0.05) is significant. Under the two given condition C1 and C2, task completion times are compared. We have 13.55 minutes mean having 2.55 standard deviation (STD), and 10.59 minutes with 2.82 STD, with significant ANOVA. The outcomes show that C2 has an effect and improves/enhances students' performance in CVLE for conducting chemistry lab. C2 enabled the students to accomplish the task in less time and with less no, of errors. Finally the results show that C2 has an influence and increase user's performance in CVLE as shown by mean task completion time in **(Fig.5).**

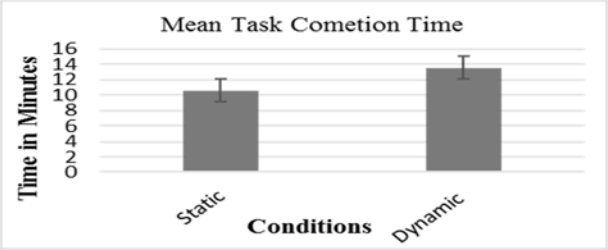


Fig. 5 Mean Task Completion Time

Errors in Task Completion Time

When the subjects pick wrong chemical and apparatus and make a wrong solution rather than the specified one, during task achievement, it is considered as an error. The number of errors was recorded during the experiment under the given conditions for task achievement. For conducting the experiments under two given conditions for task accomplishment the global error analysis for each condition is presented in **(Fig.6).** The C1 has average of 3.78 errors with standard deviation 1.34; C2 has 2.14 errors with standard deviation 0.82. The results show that C2 has low errors than C1.

Subjective Assessment

In this section responses collected via questionnaire based survey are analyzed **(Table I and Table 2).** In Table I, survey questions are presented where for each question the subjects had to select an option from the given two.

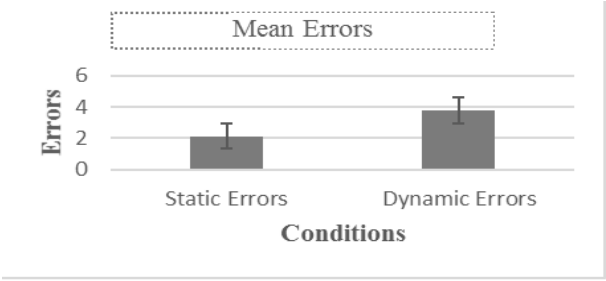


Fig. 6 Mean Errors

Table I. Learning Question about CVLE

No	QUESTIONS
Q1	In which task distribution method your concentration on learning was high?
Q2	Which task distribution method do you prefer for learning?
Q3	In term of memorability, which task distribution method is more useful?
Q4	In which task distribution method you were more involved in the experimental activities?
Q5	Which task distribution method motivates you more to perform the experiment in CVLE?
Q6	In which task distribution you learn more about the procedure of the experiment?
Q7	In which task distribution the collaborator activities were more visible to you?
Q8	In which task distribution you need more communication with your collaborator?

Table 2. Responses and Statistical Assessment of CVLE base on Table I (Participants= 44)

Q. No	Static	Dynamic	Q. No	Static	Dynamic
Q1	41%	59%	Q5	18%	82%
Q2	23%	77%	Q6	9%	91%
Q3	36%	64%	Q7	23%	77%
Q4	9%	91%	Q8	14%	86%

For Q1, 41% subjects favored C2 while 59% chose C1. For Q2, conditions C2 and C1 obtained the preference of 23% and 77% subjects respectively. For question no.3, 36% of the subjects chose C2 and 64% chose C1. To Q4 only 9% of the subjects were involved in C2 while the remaining 91% students were involved in C1. According to question no.5, student's motivation level for C2 accomplishment is 18% while it is 82% for C1. To learn the procedure of the experiment student ratio for C2 is 9% and 91% is for C1. As far as Q7 is concerned, 23% chose option C2 and 77% selected C1 and for Q8, only 14% students chose C2 and remaining 86% chose C1.

From the Table II, we observed that dynamic task distribution mechanism significantly increase user's learning capability as compared to static task distribution.

5. CONCLUSION

In this study we developed a collaborative virtual learning environment (CVLE) for conducting chemistry

experiments. This CVLE is helpful for educational institutions where students can simulate their chemistry experiments like a real world chemistry laboratory, particularly in developing countries where financing is the main issues.

Although the result of this study shows that, static task distribution is useful for performance of the users in CVEs and dynamic task distribution mechanism is useful for learning perspective. Whenever the user performance is the main motives for executing the task in CVEs, static task distribution mechanism should be adopted and whenever learning is the main objective to execute task in CVEs then dynamic task distribution will be preferred. Compared to preceding works of researchers in field of CVEs our CVLE is easy and flexible in using and understanding the environment. In future work, latency which is important factor for increasing user performance in CVEs will be checked based on task distribution model.

REFERENCES:

Alexander, P. M. (2006). "Virtual teamwork in very large undergraduate classes." Computers & Education **47**(2): 127-147.

Ali, N., S. Ullah, A. Alam and I. Rabbi (2015). The Effect of Multimodility and 3D Interaction in a Virtual Laboratory on Students' Learning in Chemistry Education. Sindh University Research Journal (Science Series), 47(4), 703-708.

Bijlani, K., P.V. Rangan (2011)Real-time Collaborative Virtual Interactive E-Learning Environment. 2nd international Conference on e-Education, e-Business, emanagement and E-learning (IC4E 2011), Mumbai, India.

Bouras, C., E. Giannaka, (2005). Designing virtual spaces to support learning communities and e-collaboration. Fifth IEEE International Conference on Advanced Learning Technologies (ICALT'05), IEEE, Kaohsiung, Taiwan.

Bruner, J. S. (1990). Acts of meaning, Harvard University Press.

Dalgarno, B., A. G. Bishop, (2012). The potential of virtual laboratories for distance education science teaching: reflections from the development and evaluation of a virtual chemistry laboratory. Proceedings of The Australian Conference on Science and Mathematics Education (formerly UniServe Science Conference), Sydney, Australia.

Garrison, D. R., T. Anderson, (2001). "Critical thinking, cognitive presence, and computer conferencing in distance education." American Journal of distance education 15(1): 7-23.

Kurillo, G., (2008). Immersive 3rd environment for remote collaboration and training of physical activities. IEEE Virtual Reality Conference, IEEE, Reno Nevada, USA.

Lee, E. A.-L., K. W. Wong, (2010). Learning with virtual reality: its effects on students with different learning styles. Transactions on edutainment IV, Springer**:** 79-90.

Limniou, M., D. Roberts, (2008). "Full immersive virtual environment CAVE TM in chemistry education." Computers & Education 51(2): 584-593.

Mark Brouard. "Oxford University Virtual Chemistry Lab. (2015) ."Retrieved 26 November, , from http://www.chem.ox.ac.uk/vrchemistry/

Monahan, T., G. McArdle, (2008). "Virtual reality for collaborative e-learning." Computers & Education 50(4): 1339-1353.

Peck, B. and C. Miller (2010). "I think I can, I think I can, I think I can I know I can Multi-user Virtual Environments (MUVEs) as a means of developing competence and confidence in undergraduate nursing students An Australian perspective." Procedia-Social and Behavioral Sciences 2(2): 4571-4575.

Shi, Y., W. Qin, (2010). Smart classroom: Bringing pervasive computing into distance learning. Handbook of ambient intelligence and smart environments, Editors: Hideyuki Nakashima *et al.* Springer: 881-910.

Spellman, P. J., J. N. Mosier, (1997). Collaborative virtual workspace. Proceedings of the international ACM SIGGROUP conference on Supporting group work: the integration challenge, ACM, New York, Phoenix, AZ, USA.

Temel, H., B. Oral, (2000). "Kimya ogrencilerinin deneye yonelik tutumlari ile titrimetri deneylerini planlama ve uygulamaya iliskin bilgi ve becerileri arasndaki liskinin degerlendirilmesi." Journal of Contemprory Education 264: 32-38.

Tsovaltzi, D., N. Rummel, (2010). "Extending a virtual chemistry laboratory with a collaboration script to promote conceptual learning." International Journal of Technology Enhanced Learning 2(1-2): 91-110.

Zhong, Y. and C. Liu (2014). "A domain-oriented end-user design environment for generating interactive 3D virtual chemistry experiments." Multimedia Tools and Applications 72(3): 2895-292