IDEA GROUP PUBLISHING
701 E. Chocolate Avenue, Suite 200, Hershey PA 17033-1240, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com

ITB12714

This paper appears in the book, *Emerging Trends and Challenges in Information Technology Management, Volume 1 and Volume 2* edited by Mehdi Khosrow-Pour © 2006, Idea Group Inc.

Application of a Collaborative Virtual Environment for Learning Molecular Biology

Miguel A. Garcia-Ruiz, Ricardo Acosta-Diaz, Maria Andrade-Arechiga, & Juan Contreras-Castillo
School of Telematics, University of Colima, Ave. Universidad 333, Colima, 28040, Mexico, P/F 52 312 31611075
{mgarcia, acosta, mandrad, juancont}@ucol.mx

ABSTRACT

This paper explores a collaborative virtual environment (CVE) applied to support molecular structure learning. Due to many students of all levels have difficulty understanding the structure of molecules and other information in molecular biology and biochemistry courses, CVEs seem suitable to support its learning, because students can inspect virtual models of molecules, as well as learning in collaboration. In addition, literature reports that virtual reality has been used in education to facilitate learning of abstract or complex information with positive success. We started a research project that used virtual environments containing virtual molecules of DNA and amino acids. They can be studied by students using the local network and the Internet, thus many students could benefit. A pilot usability study was set up, in which preliminary results shows ease of molecule analysis and communication among students.

1. INTRODUCTION

Chemistry students of all levels have difficulty learning and understanding biochemistry concepts due of its abstractness, as in the bonding of two molecules (Birk and Kurtz, 1999). The problems of learning molecular structure are basically due to incomprehension of molecular scale, difficulty of perception of three-dimensional features, and complexity of molecular bonds, among others (Dor and Barak, 1999; Birk and Kurtz, 1999). Plastic and wood model sets have been used for learning and teaching molecular structure since the fifties, but they present a number of disadvantages, such as inaccuracy of scales and bond angles, difficulty to manipulate and store, and incapacity to show some molecular properties such as bond order (Petersen, 1970).

Since the eighties, computer-assisted learning (CAL) programs, especially multimedia and computer-based graphical representations, have been commonly used in classrooms and computer rooms to support learning of molecular structure, using stand-alone molecular visualizations and modelers. One of the most popular and free molecular visualization program is Rasmol, developed by Roger Sayle in 1996.

With the widespread use of the Internet starting in mid nineties, molecular visualizations have been easily done by groups of students, downloading graphical representations of molecular structures from Web pages or collaboratively watching and analyzing the same molecular graphic using plug-ins for Web browsers (Rzepa et al., 1997).

Recently, virtual reality (the 3D graphical simulation with interaction) has been used for analyzing and learning molecular structure and bonding. Stand-alone applications have been developed and used to support comprehension of bond formation, molecular site receptors, and amino acids structures (Su and Loftin, 2001; Sherman and Craig, 2003). However, there is limited research on the benefits of learning molecular structure using collaborative virtual environments. In addition, this technology has been successfully used in a number of educational areas for reinforcing complex or abstract concepts and for simulation, such as in Zoology (Allison et al. , 1997), Algebra (Bricken, 1992), atomic models (Byrne, 1996), and others, to name some. With virtual reality, students can understand abstract or complex concepts in a new way, using various sensory channels, thus supporting the learning process (Dede et al, 1997). In addition, Virtual reality technology can make concepts more explicit and concrete, recreating situations or concepts that can be difficult to do in a real environment (Dede et al, 1997; Sherman and Craig, 2003). For example, a student could explore a virtual atomic structure with virtual protons, and virtual electrons moving around its core (Byrne,1996).

2. USABILITY STUDY

A series of virtual environments are being developed, containing virtual molecules of DNA (Deoxyribonucleic Acid) and twenty basic amino acids. These molecules were chosen because they are widely studied in biochemistry and related courses (Cohen, 2003). The data for making the virtual molecules were obtained from PDB (Protein Databank) files downloaded from the RSB Protein Data Bank website (Berman et al., 2000). The virtual molecules were shown using a virtual environment browser called DIVE (Distributed Interactive Virtual Environments) (Carlsson and Hagsan, 1993). DIVE is a free VR browser, which has its own language, and also can handle Tcl/Tk and VRML (Virtual Reality Modeling Language) scripts. It can be downloaded from http://www.sics.se/dive/. Students access a virtual environment made in DIVE through a local network or the Internet, where they are represented in the environment as avatars (a graphical personification of a student), as well as to communicate each other using a text chat window, and using the voice with a microphone. In this manner, a virtual molecule can be shared, seen, analyzed, and manipulated by all the students. It is possible to use other virtual reality browsers and programming libraries to do collaborative learning such as VR Juggler (Cruz-Neira et al., 2002), but we consider they are more difficult to program and configure than DIVE.

A usability study was carried out to get first insights of the visualization of virtual molecules, as well as the analysis of the use of the collaborative virtual environment. Eight Computer Science students were asked to participate in the study. They had very basic knowledge of molecular

Figure 1. Some virtual molecules shown in DIVE browser.

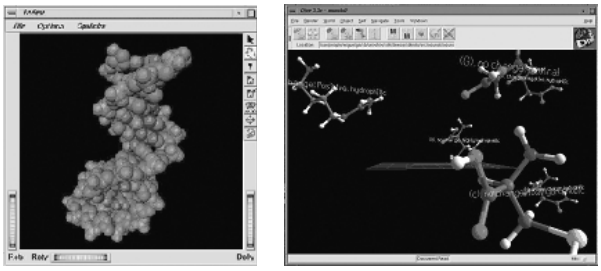


Figure 2. Configuration of the collaborative virtual environment.

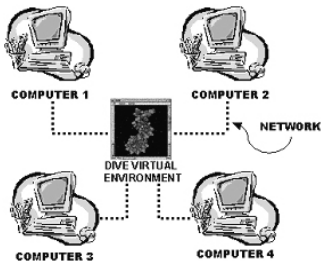
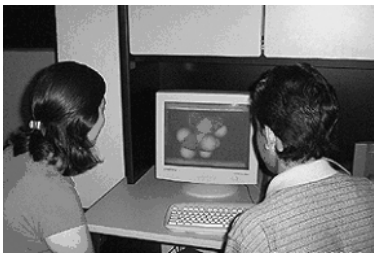


Figure 3. Students analyzing a view of virtual molecule of DNA.



structure. A virtual molecule of DNA was chosen for this test because of its particular structural features, such as amino acids conformation, helicoidal structure, and other features described in Cohen (2003). A usability questionnaire was designed with four open questions and five Likert scales to obtain information about participants' demographics, video games previous experience (to see if this could affect participants' performance in the study), possible discomfort in the visualization, ease of watching the structural features, preference, and collaboration.

For this study, participants were asked to use four computers with Windows 2000 operating system, connected to a local network running at 100Mbps (See Figure 2.). All the computers were at the same room, situated one another approximately 5 meters apart. The students were seated in pairs in front of each computer (Figure 3). All the students were sharing the same virtual environment showing a DNA virtual molecule, which was seen and manipulated using DIVE browser. A chemistry teacher (acting as a moderator) explained DNA's main molecular structural features, such as conformation, chirality, chemical composition, bonding, and others, as the molecule model was rotated. The teacher explained the virtual molecule using the text chat system of DIVE, and showed the molecule from many angles and from the inside of the DNA molecule, as well as zooming in and out, as he was explaining the structure. The molecule explanation lasted about 30 minutes. During the explanation, students could ask the teacher or to another student about the virtual molecule using the text chat window or their voice using the microphone. After the explanation, students were asked to fill in the usability questionnaire.

3. PRELIMINARY RESULTS

Most of participants declared in the questionnaires that it was very easy to watch the molecular features on the computer screen, even though four of them answered in the questionnaire to have a sight problem (myopia and astigmatism). All students positively responded to a question that asked how useful collaborative VR should be to learn molecular structure in chemistry courses. Regarding the preference questions, all students preferred to learn biochemistry using VR in conjunction with other didactic media, such as multimedia and Web pages. 65% of students declared that using the keyboard arrow keys was very easy to change the view point of the molecule. However, 45% of students shown problems with the communications using the voice. 90% declared that the chat window was very useful for comments exchange on the virtual molecule.

4. DISCUSSIONS

All of students declared in the questionnaire that they preferred to learn biochemistry using a collaborative virtual reality environment in conjunction with other technologies, such as multimedia CD-ROMs and Web pages. Most students strongly prefer the use of VR to learn biochemistry than from traditional pedagogical tools alone (i.e. the blackboard). In addition, it was noticed that students shown an increase of their participation, especially interest and collaboration, compared to activities done in a conventional classroom. This increase of participation and interest using a computer-mediated communication (in this project, participants used the text messaging in the collaborative virtual environment) has been reported in other research studies using virtual reality in education (Byrne, 1996; Dor and Barak, 1999).

5. CONCLUSIONS

Initial tests of the collaborative virtual environment were encouraging. Nevertheless, it is necessary to make certain technical adjustments, such as the voice communications. This happened because we needed to increase the microphone gain, and perhaps to use better microphones. We also have to adjust the use of the keyboard for changing the viewpoint. Due to DIVE browser is free, and its computer requirements are relatively low compared to other virtual reality programs, it can be installed and used in almost any today's computer room.

6. FUTURE WORK

A study is being planned to compare a group of students without a moderator and having them manipulate and analyze the molecule, following certain predefined tasks. Further tests are needed with larger number of students, and doing tests on the Internet as well, having groups of students that could be remotely connected online. DIVE architecture is ready for working with many students on the Internet, previous installation of DIVE and proxy servers. It is necessary to do a polygon optimization to the source code of the virtual molecule of DNA, since it is a large file, and it could not be adequately displayed on remote or slow Internet accesses. Once the virtual environment system is tested and updated, we will apply it to regular molecular biology, biochemistry and related courses.

REFERENCES

Allison, D., Wills, B., Hodges, L. F., and Wineman, J. (1997). Gorillas in the Bits. *In Proceedings of the 1997 Virtual Reality Annual international Symposium (VRAIS '97)*). VRAIS. IEEE Computer Society, Washington, DC, 69.

Berman, H.M., Westbrook, J., Feng, Z., Gilliland, G., Bhat, T.N., Weissig, H., Shindyalov, I.N., Bourne, P.E. (2000). The Protein Data Bank. *Nucleic Acids Research* , 28.

Birk, J.P., and Kurtz, M.J. (1999). Effect of Experience on Retention and Elimination of Misconceptions about Molecular Structure and Bonding. *Journal of Chemical Education*, 76(1).

Bricken, W., & Winn, W. (1992). Designing Virtual Worlds for Use in Mathematics Education: The Example of Experiential Algebra. *Educational Technology*, 32, 12-19.

Byrne, C. (1996). Water on Tap: The Use of Virtual Reality as an Educational Tool. *PhD Thesis*. University of Washington, Seattle, WA.

Carlsson, C., & Hagsan, O. (1993). DIVE - A Platform for Multi-User Virtual Environments.

Computers and Graphics, *17*(6).

Cohen, J. (2003). Guidelines for Establishing Undergraduate Bioinformatics Courses. *Journal of Science Education and Technology*, 12(4).

Cruz-Neira, C., Bierbaum, A., Hartling, P., Just, C., Meinert, K. (2002). VR Juggler – An Open Source Platform for Virtual Reality Applications. *Published at 40th AIAA Aerospace Sciences Meeting and Exhibit 2002*, Reno, Nevada, January.

Dede, C., Salzman, M., Loftin, R. B., & Ash, K. (1997). *Using Virtual Reality Technology to Convey Abstract Scientific Concepts* (In Press). Lawrence Erlbaum, Hillsdale, NJ.

Dor, Y. J., & Barak, M. (1999). Computerized Molecular Modeling as a Collaborative Learning Environment. In Hoadley, C., & Roschelle, J. (Eds.), *Proceedings of the Computer Support for Collaborative Learning (CSCL) 1999 Conference*. Stanford University, Palo Alto, CA, Lawrence Erlbaum Associates.

Petersen, Q.R. (1970). Some Reflections on the Use and Abuse of Molecular Models. *Journal of Chemical Education*, 47(1).

Rzepa, H. S., Murray-Rust, P. and Whitaker, B. J. (1997). The Internet as a Chemical Information Tool, *Chem. Soc. Revs.*, 1997, 1-10.

Sherman, W. R., Craig, A.B. (2003). *Understanding Virtual Reality*. San Francisco: Morgan Kauffman.

Silverman, B.G. (1995). Computer Supported Collaborative Learning (CSCL). *Computers and Education*, 25(3).

Su, S. and Loftin, R.B. (2001). A Shared Virtual Environment for Exploring and Designing Molecules. *Communications of the ACM*, 44(12).

Winn, W. (1993). A Conceptual Basis for Educational Applications of Virtual Reality. *Tech. rep*., Human Interface Technology Laboratory, University of Washington. Report No. TR-93-9.

Related Content