Interactive Software as a Tool for Increasing Student Comprehension of Basic Chemistry Concepts

Verlese Patricia Gaither  
Wakefield High School  
Arlington County (VA) Public Schools  
Submitted June 2000

Introduction

The ideal of a multicultural education is that all students regardless of gender, social class, ethnic or cultural characteristics shall have an equal opportunity to learn in the classroom environment. In order to provide this opportunity, educators must have an appreciation for the motivations, aspirations, learning modes, linguistics, and culture of different student groups (Atwater, 1993).

This paper examines the integration of interactive software into the chemistry curriculum for purposes of increasing overall student comprehension in multicultural classrooms. To provide maximum opportunities for the greatest number of students to learn science, it is important to adjust the classroom climate by introducing multiple teaching strategies or modes. In acknowledgement of this idea simulation-based software was used to involve multi-sensory delivery – visual, audio, and kinesthetic. The motivation for the study was primarily poor student performance on the 1999 Virginia Standards of Learning exam (S.O.L).

Initially various computerized aids such as Internet based tutorials, quizzes, text-based ‘drill and practice’ programs, and the provision of notes using PowerPoint presentations were tried. From the delivery of these lessons it was clear that my students enjoyed instruction augmented with technology. In October 1999, Riverdeep’s Logal SimLibrary was added. Riverdeep’s interactive learning technology consists of simulations based on mathematical models to teach science. Within Riverdeep’s Logal SimLibrary there are two levels of activities; “Chemistry Gateways” for students in introductory level courses and “Chemistry Explorer” for students in advanced placement courses. The “Chemistry Gateways” activities were selected because they presented lessons in structured formats at a level that felt to be more suitable for the students in my course.

Background

The simulation models used were interactive exercises that provided visualizations in real time of a physical system or process. For every simulation model, there is a predefined set of input variables. Changing the starting values of these variables can set up different simulations. The results of the new values are reflected when the simulation is run. Students can change the parameters of an experiment as the simulation runs, or repeat an experiment multiple times with different parameters (Reeves, 2000). For the student, simulations provide a
visually dynamic representation of a concept and can aid a student in the development of practical and understandable mental models. It is through these models that a student can better understand, master and apply a particular concept. In addition, simulations can assist a student in the building of science process skills, critical thinking skills, and analytic skills (Thode, 1999).

It is had been hypothesized that computer-based simulations will increase student learning. A number of studies have been conducted evaluating the use of computer simulations on student learning. Many studies compared learning from unstructured “pure” simulation with learning from some form of expository instruction (computer tutorial, classroom) covering a variety of domains, such as biology, (Rivers & Vockell, 1987), economics (Grimes & Willey, 1990), electrical circuits (Carlsen & Andre, 1992; Chambers et al., 1994) and mathematics (Nicaisse & Barnes 1996). Grimes and Willey (1990) and Nicaisse and Barnes (1996) reported favorable results for simulation-based learning. Carlsen and Andre (1992), and Chambers et.al. (1994), found no difference between simulation-based learning and expository teaching. Rivers and Vockell (1987) found a mixture of favorable results and no-difference in several sub-studies. The general conclusion that emerges from these studies is that there is no clear and unequivocal outcome in favor of simulations.

Subjects

The subjects were seventy 11th and 12th graders in lower ability Principles of Chemistry classes. The student demographics were as follows: 47% Hispanic, 29% African American, 13% African, 5% Caucasian, 3% Asian American, and 3% Middle Eastern.

Instruments

Pretest and posttest were used to measure effects of technology on student learning. The pretest consisted of ten true/false questions administered prior to the intervention (simulation) and after the introduction to the topic by the teacher. The posttest was administered after the intervention. On the posttest the same ten questions as were asked on the pretest. Sample questions are shown below:

### Pretest/Posttest Logical Questions: Properties of Gases
Answer True or False to the following statements.

1. Pressure must be exerted on a sample of gas in order to confine it. T / F
2. Gases diffuse into each other and mix almost immediately when put into the same container. T / F
3. Pressure is defined as pressure per unit area. T / F
4. When you fill a balloon with air its volume decreases. T / F
Logal’s “Chemistry Gateways”
Interactive simulation used. Example of “The Properties of Gases” below:

Study Guide

The study guide provided questions to be used in conjunction with the simulation, to direct the students through the discovery process. Below is an example of study guide questions.

*Early Atomic Theories – An Introduction*

Instructions: Read the following and answer the questions while going through the program.

- What is an atom?
- Who was John Dalton?
- Click on the “Objectives” button. Write down the objectives of the activity.
- Write down Dalton’s four postulates (In your own words).
- Dalton envisioned atoms to be hard tiny indestructible spheres, much like __________; In a solid, the billiard balls would be __________.
• Look at the picture of the coin, on the right of the screen. According to Dalton, what do you expect to see if you magnify the coins many times? (To check your prediction, click on the magnify the coin.)

Attitude Survey

An attitude survey was administered to measure students' feelings about the use of technology in their studies. The survey consisted of 15 statements indicating positive or negative attitudes towards the software. For example, Logal's 'Gateways' helped reinforce concepts taught and Logal 'Gateways' provided different approaches for presenting information. To each statement, students were asked to respond on a five-point scale ('strongly agree', 'agree', 'neutral', 'disagree', and 'strongly disagree'. Responses were scored 1, 2, 3, 4 or 5, with a high score indicating a strongly positive attitude (See appendix I for complete instrument).

Personal Journal

The personal journal described the pros/cons of using computer-based instruction tried in the classroom (See appendix 2).

Student Assistant Observations

The source of the student observations was an individual who for her senior project examined teaching strategies employed in preparation for the S.O.L exam in Principles of Chemistry (See appendix 3).

Procedure

Prior to each simulation, all students took a pretest and then turned them face down on their desks. For each class the lesson began with a whole class activity lasting around 15 minutes. The aim of this session was to introduce the topic and give the students a common starting point. By making the subject matter relevant to students in the introduction to each new topic, interest was generated. For example, when introducing the topic the “Properties of Gases,” the question was asked collectively, “what happens to your ears as you ascend in an airplane?” Everyone responded, “It pops!” This generated interest on the part of the students, as they all wanted to know why.

A ‘Think-Pair-Share’ teaching activity was then employed as follows: The students were asked to write down the explanation for the observation. This was done individually. The students were then asked to share with a partner, and then share with the class. Worksheets were handed out for each assignment. The main goal of the worksheets was to help students present their solutions and provide the teacher with a familiar way to follow and evaluate students work. Each worksheet consisted of the task presentation and places for writing the data and explaining the solution. The data and the simulation results were not presented on the worksheet, therefore they could not be used without actually operating the simulation. At the end of each simulation, the material was
summarized, allowing for introduction of correct terminology and to find out how well the students had grasped the topic.

After the activity the posttest was administered. Both the pretest and posttest were self-checked by the students. After each topic, a matched-pair of Student’s \( t \)-Test was performed on pretest and posttest data, matching each student’s posttest score with his own pretest score to determine whether there was a statistically significant difference between posttest and pretest scores. Approximately a week after completion of all Logal assignments the attitude survey was administered anonymously.

Results

**Attitude Survey.** Mean scores for the attitude survey (1 = strongly disagree, 5 = strongly agree) suggested that most students like using the computer program (M = 4.42), and thought it augmented the teacher’s instruction (M = 4.35). Students indicated that the information was presented in an understandable manner (M = 4.01), but were undecided as to whether the activities helped them prepare the Virginia’s Standards of Learning exam, (M = 2.98). However, the students thought the software was appropriate for Principles of Chemistry students (M = 4.12), and would recommend it for other chemistry students (M = 3.98).

**Mean Differences in Scores: Pretest versus Posttest.** Tested was the mean difference in student scores between the pretest and posttest for three topics studied. For each of the three topics students scored significantly higher (P=0.05) on the posttest when compared to the pretest. On the first topic ‘Structure of the Atom’ the mean scores on the pretest were M=6.29 versus the posttest with mean scores of M=8.33 (P=.000; st.dev =1.4). For the topic ‘Lewis Structures’ the mean scores on the pretest were M=7.48 versus the posttest with mean scores of M=8.13 (P=.013; st.dev =1.15). Finally for the topic ‘Properties of Gases’ the mean scores on the pretest were M=6.03 versus the posttest with mean scores of M=6.87 (P=.0004; st.dev =1.17).

Discussion

The objective of this project was to determine if computer-based interactive simulations increased student learning in multicultural classrooms. The data indicates that there was a significant difference between pretest means and posttest means. However, from the test results one could not say with certainty whether the difference was directly or singularly linked to learning from the simulation and not just due to chance or extraneous factors (teacher introduction, class discussion, other), because there was no control group; i.e. one to whom the simulations were not administered. In addition, only three topics were used in the study, the other topics studied as part of the curriculum were not included. It is not known if all of the simulation activities would have produced the same results, because each one is different. Some are longer than others and some cover concepts that require higher level thinking, such as stoichiometry.
Students’ views revealed that most preferred using the simulations, finding them more interesting and effective than traditional instructional methods. Students realized the ability of a simulation to provide them freedom and flexibility that enabled them to take more responsibility for their learning. In addition, students commented that the interactive work helped them to be more focused and to “find out about a topic themselves instead of just listening about it” and the comment, “It makes the class more interesting” was used by several students. The student assistant also echoed these findings in her observations. The technology also proved to be a valuable classroom management strategy, because the students were actively engaged when working on the computers. Student talking and horseplay in general was minimal.

“Chemistry Gateways” may have been successful for multicultural students for the following reasons. First, it did not assume prior knowledge. Next, the concepts were clearly represented. Third, there were a high number of colorful visuals. Finally, the user has control over the simulations, thus the same simulation model can be run as many times as the student desires until they understand the concepts.

Approximately 15% of my students have learning difficulties and took longer than the time allotted to complete assignments. To accommodate them, a new middle-school level “Chemistry Gateways” which was introduced in the early part of 2000 could be used, which covers the same topics but at a lower reading level. A more structured simulation environment would be provided to promote a positive learning outcome for these students. Prior to the activity, background information will be given. Lack of prior knowledge might be the reason that learners do not grasp concepts or cannot make a good interpretation of data especially when learning by discovery. Students in general and multicultural ones in particular appear to do better when given structure. The students were grouped (maximum group size two students), randomly assigned. In the future, students of mixed ability will be paired so that the faster student may help the slower student.

The use of the technology is well suited to my classes because of special problems such as absenteeism. Missed assignments may be made up during and after regular school hours either in the school computer lab or the library, as Riverdeep is installed on all computers.

As we approached the S.O.Ls, the program was used as a presentation tool during the course of regular instruction to cover some topics that had not been covered due to time constraints. At the time of writing, the S.O.L results had not arrived at school. A tentative date of June 16th was given. The software was definitely of use in preparation for the exam, more for review than for presentation however.

Major drawbacks encountered when using the program were length of time to download the CD-ROM, availability of the Internet in general, and the site (Riverdeep) in particular. Students, multicultural or not, demand instant gratification and expect to start the program at the click of a mouse. If this does not happen, they become frustrated and inattentive and it is difficult to keep them on task. In order to alleviate this problem, the computers could be prepared
beforehand. However, this would prove to be somewhat time consuming, unless the computers were networked in such a manner that they could be downloaded simultaneously. Another drawback was that Riverdeep’s SimLibrary did not cover some of the course objectives including “States of Matter” and “Acids and Bases.”

Final Comment

I have reported here my experience with Riverdeep’s interactive technology. The technology gave me the opportunity to engage students in meaningful discovery learning. Students are habituated to passively listening to lecture, writing notes and taking multiple-choice tests. Using the technology, students have to think more and work harder which should ultimately lead to increased understanding. The enthusiastic response of my students has encouraged me to continue to incorporate it, with appropriate modifications, in the future. I will endeavor to improve upon my assignments, specifically providing a glossary and/or rewording to make assignments easier to read and understand. The comments and suggestions of the students, via students’ surveys and interviews will be used also in activity revisions. The addition of the simulations have certainly been positive for my classes, not only because it provides another method of presenting the subject matter, but also because the students genuinely enjoyed the learning experience and being able to use the computers. The largest challenge will be measuring and documenting student understanding.

References


*Appendices available upon request.*