

Position Paper:

Simulated Labs are as Effective as Traditional Labs

LT 741

Introduction to Distance Education

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## Abstract

This paper is a position paper that defends the position that simulated laboratory experiments are as effective as traditional laboratory experiments. The literature and research indicate that under certain conditions, a simulated laboratory experiment can be as effective, and in some cases, more effective, than traditional laboratory experiments. The conditions for use of simulated laboratory experiments include distance education, lack of funding for proper traditional equipment, lack of a qualified instructor, learning of specific scientific skills, supplementing a traditional laboratory curriculum and lack of a real-world experience.

## Introduction

In today's technological society, we depend on the computer for virtually everything. From pumping gas to checking out at the local grocery store, computers are being used. In the educational environment, the computer is becoming more and more a common piece of equipment. The computer can be used as a tool for gathering and presenting information. It can be used to gather data in a laboratory setting and then help synthesize the data for further consideration. External probes, such as temperature sensors, motion sensors, pH sensors, etc., can be connected to the computer for this process. Even traditional experiments require sophisticated equipment for advanced experiments. But what if a school doesn't have the technology or the budget to purchase all of the technology required for the experiment? What can be done in place of this equipment?

I believe that simulated laboratory experiments can be an effective substitute for traditional laboratory experiments. Schools may choose to use simulations for various reasons. The reasons may include monetary savings within the district or college, remoteness of the school, a more practical approach to a topic that may be too complex due to size, location or safety issues, or simulations can better represent the topic than a traditional experiment.

## Distance Education Implementation

The need for virtual classrooms can occur for many reasons. In remote areas, the number of highly qualified teachers for all subjects is few and far between. Distance education classrooms and simulated labs are a solution to this problem. In Alaska, biology teacher Andrea Pokrzywinski uses distance education techniques to teach fetal pig dissection. She uses an

internet-based program for the dissection. She is teaching at a distance from Bethel, Alaska to many villages in the Lower Kuskokwim School District using synchronous two-way video and audio connections to all classrooms (McCabe, 2009).

Ms. Pokrzywinski is educating about 100 students using this method. The individual classrooms each have a proctoring teacher to assist the students with any issues that may arise. The students are reluctant at first to converse using the distance technology, but do warm up to the idea over time (McCabe, 2009). In a society where the students are constantly being entertained, it is understandable that this method of instruction may seem boring to them. Even in traditional classrooms, it is difficult to hold the attention of the students.

The utilization of simulated laboratory experiments at a distance fills a gap that would otherwise be left open in remote areas. By using distance education coupled with simulated laboratory experiments, school districts can complete their curriculum requirements without spending the dollars that would be necessary to place a qualified science teacher in each school. Also, the school districts save money by not having to purchase the necessary laboratory equipment that would otherwise be necessary in a traditional classroom.

The effectiveness in a situation like this needs to be considered not in just student achievement, but also in affordability and practicality for the school districts that, at times, can only be accessed by small aircraft. The students are getting the same curriculum, just in a different manner. They are being taught by a certified instructor in the subject area. The school districts are doing the best they can with what they have. Using simulated labs with an

instructor teaching at a distance via two-way audio and video may be the best alternative to having a qualified teacher in each classroom in each remote school.

### Learning Specific Scientific Skills While Saving Time and Money

Computer lab simulations can aid students' understanding of an experiment because it can give them stronger visual and mental images (Eichinger & Others, 1997). In the natural sciences, many situations can be very difficult to reproduce, due to costs of materials, transportation to appropriate locations, or the physical nature of the animal, object or location being studied. By using laboratory simulations, students can manipulate variables, receive computer generated data and process this data to receive results. These scientific techniques can all be done by a computer simulation, without having to spend the large amount of money to have the students do the experiment in the real world. And they will get the same skills by doing this in the computer laboratory.

When students do traditional laboratory experiments in high school and college, they can be overwhelmed by the experimental procedures and techniques required to complete the experiment. They have trouble making the connection from what was taught in lecture to applying it in the laboratory. The purpose of the lab can be lost. The procedures can be confusing. The students are not observing what they should be observing. The students may have difficulty in relating the observed data to the purpose of the experiment (Eichinger & Others, 1997). The simulation can guide them through the procedure, making references to what was taught, guiding them towards the desired results.

By using a computer simulation, the students can run and rerun the simulation to catch anything that was missed when the experiment was executed. In a traditional laboratory experiment, there may only be time to do the experiment once. And the materials may be too costly for the school to have students doing these experiments over and over. A computer simulation alleviates these problems.

Eichinger and others surveyed the students in their study and found that students perceived the computer as a new way to gain knowledge, allowed them to visualize difficult concepts, and allowed the students to work at their own pace. Also, students responded that they found the computer to help them understand the experiment, agreed that the computer has importance in science, and the displayed data in the simulation help them understand the ideas presented in the experiment (Eichinger & Others, 1997).

The computer may be allowing the students to not be so critical of what they are doing. They know that what they are doing is a simulation and that if they make a mistake, it may not be as dangerous as a real experiment, as in a chemistry lab. And if a mistake does occur, they can reset the simulation and try again. By doing this, the students are learning from their mistakes and it isn't costing money or possibly time. So the experiment can be done with the focus on the purpose of the lab and not on doing the experiment exactly as the instructions say on the piece of paper.

#### Supplementing Current Laboratory Curriculum

In a study done by Michael L. Burchfield and Vernon D. Gifford of Mississippi State University, the effect of computer-aided instruction (CAI) was tested. Their results showed that there was

no significant difference in gains by the control group or experimental group, except in graphing and data interpretation. The experimental group, which was the group that used the CAI, showed improvement in the area of graphing and data interpretation on their post-test (Burchfield & Gifford, 1995).

In this study, two sections of students were used. Half of each section was randomly selected into the control group. The other half of each section was randomly selected as the experimental group. Each control group from each section completed commercially produced computer tutorials designed to improve student's understanding of content. Each experimental group from each section completed two CAI modules designed to improve integrated science process skills, such as observing, measuring, inferring, classifying and predicting (Burchfield & Gifford, 1995).

Four null hypotheses were tested. Only one was rejected. The study did show that there was no significant gain in integrated science process skills, which was predicted. But the null hypothesis that was rejected showed that the experimental group did score significantly higher in graphing and interpreting data (Burchfield & Gifford, 1995). So their experiment was successful in showing that computer-aided instruction, which is a simulation, can be as effective as other methods of instruction, even if the other method of instruction in this experiment was computer-based. The gain in graphing and interpreting data while using a computer simulation can be a supplement to a traditional laboratory experiment or a pre-lab technique to aid in the application of an experiment.

## Student Achievement

In a study done by Kelly, Bradley and Gratch, it was discovered that there was no significant difference in achievement between simulated laboratory experiments and traditional laboratory experiments, although final lab report scores were higher on simulated lab reports. However, students didn't prefer one method over the other. They responded that both simulated laboratory experiments and traditional laboratory experiments were beneficial in their own way. Traditional labs provided the hands-on experience that the students preferred. Simulated labs provide an easier way to do a lab experiment (Kelly, Bradley, & Gratch, 2008).

The results from this study were based on a number of lab experiments. Five labs out of six showed increased report scores when simulation was used (Kelly, Bradley, & Gratch, 2008).

This result may demonstrate that the topic being studied was more conducive to one type of lab or another. The simulation may not be appropriate for the type of calculations required or measurements needed for adequate data analysis. Or the simulation did not adequately portray the real-world situation it was designed to portray. This can lead to confusion on the part of the student.

In regards to student attitudes, the study didn't reveal that attitudes towards physics improved because of the use of simulations. In fact, the results from the pre-survey to the post-survey regarding attitudes revealed that students were more motivated by academic achievement (final grade) than by their attitude towards physics (Kelly, Bradley, & Gratch, 2008). I believe more work needs to be done on this. I would think that the attitudes towards physics would



improve when student success increases. When five out of six lab report scores increased on average, a better attitude would follow.

#### Limited Use for Students

Logical thinking skills may play an important role in the effectiveness of simulated labs. In a study done by Schoenfeld-Tacher; Persichitte and Jones, simulated labs were equally as effective for all students and may be effective replacements for traditional labs in areas that do not have the capabilities for a traditional lab without having negative effects on the majority of students. Simulated labs were also found to benefit those that possessed greater logical thinking skills (Schoenfeld-Tacher, Persichitte, & Jones, 2000).

This study was done at four institutions. Variables tested as predictors of student success were course rank, frequency of computer use and cognitive abilities. All predictors demonstrated that "Goal-Based Scenarios" (simulated labs) were effective for all types of students. However, the study did demonstrate that students with increased logical thinking skills were more successful when doing the GBS than those with average logical thinking skills (Schoenfeld-Tacher, Persichitte, & Jones, 2000).

The results show that simulated labs can be used with all students and can be an effective replacement for traditional labs. Those with higher level thinking skills will benefit more from these types of experiments. The effectiveness does not depend on computer aptitude. Students with different computer backgrounds were shown to be equally as successful as those with greater computer-use skills. The implication here is that simulated laboratory experiments can be used more effectively with the correct level of students.

Upper level classes may benefit more from simulations than introductory classes. The students in upper level classes, whether in secondary or post-secondary, have chosen their educational path. Therefore, their academic skills are more sharpened in their academic field. Simulations that are specific to their field of study may be more beneficial due to this increased level of knowledge and thinking in a specific area of study.

### Simulating Real-World Experiences

In a review by Dr. Sami Sahin, he states that “Computer simulations give students the opportunity to observe a real world experience and interact with it.” Some topics of study may be too dangerous or too long term for students to study using traditional methods (Sahin, 2006). By utilizing computer simulations, students can readily observe the results of dangerous situations without putting themselves in harm’s way. In a physics laboratory, rocketry could be simulated with today’s computer technology without having to be concerned with safety until the final prototype has been developed for real testing. In a microbiology laboratory, the effects of an outbreak of a dangerous virus could be simulated in a short period of time without the dangers of exposing living beings, thereby saving time and lives. These real world situations and many others can be beneficial to students when time or danger may be a factor.

Simulations for real world experiences have been used for quite some time at the elementary levels. “The Oregon Trail” video game has been used for years to teach elementary students what life was like in the late 1800’s for pioneers traveling on the Oregon Trail. Situations like these cannot be reproduced easily, especially due to the time in history. A simulated experience can help students experience as close to reality and time as possible what

conditions exist or did exist and allow them to make choices based on certain variables. This is what real life decision-making is all about.

## Conclusion

Simulated laboratory experiments are as effective as traditional laboratory experiments, with some limitations. The proper utilization is the key to a successful simulated lab. The use of simulated laboratory experiments in a distance education setting can be deemed effective if there are not other options. The effectiveness may also be a cost-savings to a school district or college that otherwise may not be able to offer a laboratory science course.

Simulated laboratory experiments can be used to gain specific science skills, such as data interpretation and graphing. They may also be used when the topic may be very difficult to understand without the simulation. Also, if the topic of study will take a long period of time, or if the situation is deemed dangerous, a simulation can save time and also lives.

Simulated laboratory experiments have been shown to be as effective as traditional laboratory experiments in regards to student achievement. In some instances, the simulation may be more effective if used with students that have better logical thinking skills. Otherwise, the studies have shown that there is no significant difference for the average student.

Overall, simulated laboratory experiments are as effective as traditional laboratory experiments if used for the correct situation. With computer technologies becoming more affordable and available, I predict that there will be a greater use of simulated laboratory experiments in the future.

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