Chen, C.-H., & Howard, B. (2010). Effect of Live Simulation on Middle School Students' Attitudes and Learning toward Science. *Educational Technology & Society, 13* (1), 133–139.

Effect of Live Simulation on Middle School Students' Attitudes and Learning toward Science

Ching-Huei Chen and Bruce Howard*

Graduate Institute of e-Learning, National Changhua University of Education, Changhua City, Taiwan // chhchen@cc.ncue.edu.tw

*Center for Educational Technologies®, NASA-Sponsored Classroom of the Future, Wheeling Jesuit University, Wheeling WV, USA // howard@cet.edu

ABSTRACT

This study examined the effect of live simulation on students' science learning and attitude. A total of 311 middle school students participated in the simulation, which allowed them to access and interpret satellite data and images and to design investigations. A pre/post design was employed to compare students' science learning and attitude before and after the simulation. The findings revealed positive changes in students' attitudes and perceptions toward scientists, while male students had more positive adoption toward scientific attitudes than females. The study also found that the change in student's science learning was significantly influenced by the teacher. Hence, teacher classroom preparation for the simulation experience proved vital to students' attitudes toward science as well as their scientific understanding. Implications for effective use of simulation to increase science-related career awareness and inform effective teaching practice are shared and discussed.

Keywords

Simulation, Science attitude, Videoconferencing, and Teaching practice

Introduction

There has been a prolonged discussion on the use of technology as cognitive tools for teaching and learning. Jonassen and Reeves (1996) characterized cognitive tools as "technologies that enhance the cognitive powers of human beings during thinking, problem solving, and learning" (p.693). Technology holds great potential for students to develop deeper knowledge and execute reflective thoughts by the specific tasks that they otherwise will not have access to. Technology also provides capabilities to complement students' learning styles and multiple intelligences.

Accordingly, simulation has emerged as one of the most popular instructional tools for delivering quality instruction. The use of realistic simulation often requires students to apply newly acquired skills while motivating them toward advanced learning (Hsu & Thomas, 2002; Lewis, Stern, & Linn, 1993; Moreno & Mayer, 2007; Weller, 2004). Frequently, students participating in a simulation perceived the experience as helpful in providing a clear context for the application of learned knowledge and in being a motivating experience (Spinello & Fischbach, 2004). Previously, Jarvis and Pell (2005) investigated the effect of live simulation experience on middle school students in the United Kingdom. They found such experience engaged students in performing expert-like thinking and acting as real scientists would to analyze and assess real-time data. Although the development of technology-rich learning environments has progressed greatly in recent years, researchers have just begun to signify the application of technology for science learning and its impact on students' achievement (Jonassen, 2003; Kim & Reeves, 2007).

In this paper, we sought to review previous research on scientific inquiry-based learning and its impact on students' attitudes toward science, evaluate how simulation would be an ideal way to support inquiry learning and promote positive attitudes toward science, and describe potential underpinning factors to optimize a successful simulation experience for students.

Theoretical Perspectives

Inquiry science learning

Scientific concepts are complex, highly technical, and often considered among the most difficult subjects to teach K-12 students. Recently, many science educators have advocated an inquiry-based approach to learning science in which students are given opportunities to actively build scientific knowledge by asking overarching questions, planning strategies, exploring solutions, constructing new knowledge, and reflecting on their own inquiry process

(Linn, 2000). The learning sciences community agrees that deep and effective learning is best promoted by situating learning in purposeful and engaging activity (Cognition and Technology Group at Vanderbilt, 1993). The goal of this study is to use the technology to mimic the real-world scientific activities and make the inquiry processes become salient to the students.

Technological Support for Science Learning and Attitudes

Several longitudinal investigations into the use of technology in students' science, technology, engineering, and mathematics (STEM) learning are ongoing, but very little attention has been given to discovering the outcomes of such endeavors (Boyle, Lamprianou, & Boyle, 2005). Technology can help in the scientific learning process because of its potential to support activities such as data collection, visualization, meaningful thinking, problem solving, and reflection. In fact, much of our current educational practice grows out of curriculum reform efforts that have emphasized the teaching of process skills involved in the construction of scientific knowledge—diverse skills such as observing, classifying, measuring, conducting controlled experiments, and constructing data tables and graphs of experimental results (Linn & Hsi, 2000). Various strategies to promote better science learning have been explored. For example, the Web-based Inquiry Science Environment (WISE) is one of the curriculum projects that Linn and her colleagues created to help students develop more cohesive, coherent, and thoughtful accounts of scientific phenomena (Linn, Clark, & Slotta, 2003). WISE is guided by an instructional framework called scaffolded knowledge integration (SKI) that requires students to reflect on their deliberately developed repertoire of models for complex phenomena, and to work toward expanding, refining, reconciling, and linking these models (Bell, 2002; Linn, 1995). In WISE, students who engage in various inquiry activities such as compare ideas, distinguish cases, identify the links and connections among ideas, seek evidence to resolve uncertainty and categorize valid relationships show better understandings of complex scientific concepts (Davis & Linn, 2000). Further research into how the effects of using technology-mediated tools to facilitate science practices, such as applying various real data to empower students to understand the scientific enterprise itself, are worth further discussion.

Researchers have long discussed whether students' positive attitudes toward science can influence whether students consider science as a career (Papanastasiou & Zembylas, 2004). Several studies have found that students' attitudes toward science correlated with science achievement and participation in advanced science courses (e.g., Lee & Burkam, 1996; Simpson & Oliver, 1990). It is also well known that students' attitudes toward a subject as well as their learning environment impact school achievement. In this study we sought to understand whether a technology-supported simulation learning environment can improve students' positive attitudes toward science subjects and careers.

Teaching Practice on Science Learning and Attitude

High-quality teachers are essential to improving the teaching and learning (Darling-Hammond, 1997). Teaching practice and instructional decisions influence the quality of students' academic performance and their motivation, effort, and attitudes toward school and academic pursuits (Hidi & Harackiewicz, 2000). They also promote or reduce students' learning and achievement (Hardre & Chen, 2005). Research involving both secondary and older students appears to indicate a relationship between teacher behaviors and students' attitudes toward science (Haladyna, Olsen, & Shaughnessy, 1982; Myers & Fouts, 1992). Children with positive attitudes toward science are more likely to be found in classrooms that have high levels of involvement, teacher support, and use of innovative teaching strategies (Myers & Fouts, 1992). Teachers who lack ability, confidence, and enthusiasm for the subject tend to use less stimulating, more didactic methods and do not respond effectively to students' questions (Osborne & Simon, 1996). Those teachers also are more likely to have students with poor attitudes toward science. Effective teachers adapt learners' needs and evaluate how information should be presented. To meet these demands, teachers need to adjust instruction to student ability levels and background. In fact, one study showed that teachers' teaching style and instructional decisions are the most noticeable factors in students' attitude toward science (Jarvis & Pell, 2005). Therefore, we surveyed teachers about their teaching practices to understand how their approaches might affect students' knowledge and attitude toward science as the result of a simulation learning experience.

The Challenger Mission: Emergency Responsive Learning Experience

The live simulation learning experience conducted for this study originates from the Challenger Learning Center at Wheeling Jesuit University in Wheeling, WV, one of more than 50 Challenger Learning Centers in the United States, Canada, and the United Kingdom. These centers for space science were created in memory of the space shuttle Challenger. More than 25,000 students fly missions each year through the Wheeling facility, and it has been honored nine times for having served the most children of all the centers.

The live simulation, or e-Mission™, is a real-world adventure delivered into the classroom via distance learning technology. With the use of the internet and video conferencing equipment, these live simulations take place in the classroom by a flight director at mission control from the Challenger Learning Center at Wheeling Jesuit University. The learning approach is a student-centered, team-based, interactive educational experience that encourages students to use scientifically accurate data to solve problems. Before the live simulation, teachers conduct a pre-mission preparation for their students, which covers all the mission materials needed for the culminating "live" event. On the mission day, students are assembled into emergency response teams. Via the Internet and videoconferencing equipment, teams connect to a flight director at mission control in Wheeling. The emergency response teams work together and with mission control to handle a "live" problem while the scenario unfolds. Every few minutes new data is delivered to the classroom. Students perform calculations, create graphs, assess the situation, and make decisions based upon their analysis of the data.

The Challenger Learning Center offers a number of e-Missions for all age groups covering mathematics, Earth science, and biology. In this study we researched teachers and students who participated in the Operation Montserrat e-Mission, which uses actual data collected during a 1996 volcanic eruption on the Caribbean island of Montserrat and during a hurricane that hit the island a few years earlier.

Methods

Subjects/Procedures

The participants were 311 (186 males; 125 females) middle school students and 7 teachers from West Virginia, Ohio, Pennsylvania, and New York. Before the e-Mission teachers attended a one-day workshop at the Challenger Learning Center, where they covered Earth science curriculum and learned about the study procedure. Teachers and students completed surveys before any mission-related activity. Teachers spent a week preparing students for the mission. Although all of the participating teachers received one-day professional training on the e-Mission, the actual classroom implementation and time allocation for the mission preparation was left up to each teacher. On the mission day classrooms connected with Challenger Learning Center via videoconferencing to interact and solve problems with a flight director. The scenario unfolds as the Soufriere Hills volcano is ready to erupt while at the same time a Category 3 hurricane is approaching Montserrat from the east. Students worked in teams to take charge of different tasks. The volcano team calculated rock fall and volcanic tectonic data to predict what would happen with the volcano. The hurricane team tracked the approaching hurricane and estimated when it would arrive on the island. The evacuation team used population maps and available transportation options to move residents out of danger zones to shelters on the island. The communications team informed mission control about the situation brewing on the island and relayed recommendations from all teams. All the data were real and sent from the satellite every 5-6 minutes. The length of the live simulation activity was approximately two hours. A week after the mission, students and teachers took the post-surveys.

Surveys/Instruments

Attitudes toward Science

Osborne, Simon, and Collin (2003) suggested that attitudes toward science is not a unitary construct, but "rather of a large number of subconstructs, all of which contribute in varying proportions towards an individual's attitudes towards science" (p. 1054). Our study used the Test of Scientific-related Attitudes (TOSRA), designed by Fraser (1978) from Klopfer's Classification (Klopfer, 1971) because this instrument contains more focused scales to measure the sub-constructs of attitude toward science among middle school students. The instruction for completing the TOSRA survey was given in the beginning: This test contains a number of statements about science. You will be asked what you think about these statements. There are no “right” or “wrong” answers. Your opinion is what is wanted. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. 5 as strongly agree (SA), 4 as agree (A), 3 as uncertain (U), 2 as disagree (D), and 1 as strongly disagree (SD). TOSRA with a total of 70 items includes seven distinct science-related attitudes. The first factor is social implications of science. Here’s a sample statement measuring it: “Public money spent on science in the last few years has been used wisely.” The second subscale is normality of scientists: “Scientists do not have enough time to spend with their families.” Attitude toward scientific inquiry is the third subscale: “I would prefer to do experiments than to read about them.” The fourth subscale is adoption of scientific attitudes: “Finding out about new things is unimportant.” Enjoyment of science lessons is the fifth subscale: “Science lessons are a waste of time.” The sixth subscale is leisure interest in science: “I would like to belong to a science club.” The last subscale is career interest in science: “Working in a science laboratory would be an interesting way to earn a living.”

Teacher Content Knowledge Covered

A content knowledge covered sheet was given to the teachers asking for the information on the kinds of topics that teachers covered during their classes and the information on the level of coverage for each science vocabulary. The ratings are: 1 as not at all mentioned; 2 as mentioned briefly in class; 3 as discussed in class or observed in homework, and 4 as covered thoroughly in class or through homework.

Student Content Knowledge Pre- and Post-Tests

The pretest and posttest each consisted of 40 items. The items represented the following categories: near transfer, far transfer, and selected items from standardized testing. In this study, the tests include two forms and contain respectable reliabilities (A=0.79; B=0.86) on the previous study (Howard, 2004). Tests were administered by participating teachers. Choice of test form and order of test form administration was left up to each teacher (i.e., A-A; A-B; B-A, B-B).

Data Analysis

A one-way ANOVA (analysis of variance) was performed to examine the changes on students’ science attitudes and learning before and after participating in the live simulation. A Pearson coefficient correlation was then conducted to examine whether there is a relationship between students’ content knowledge tests, TORSA, and teachers content knowledge covered.

Results

The one-way ANOVA showed a significant difference on the normality of scientists before and after the live simulation experience, F (1, 557) =5.00, p<.05. Table 1 presents their mean scores and standard deviations for the TOSRA and its scales. Students’ perception toward normality of scientists increased from 3.14 to 3.22.

The results showed significant gender differences on adoption of scientific attitudes and career interest in science. Male students (Mean=3.08, SD=0.42) showed significantly higher adoption of scientific attitudes than did female students (Mean=3.01, SD=0.41), F (1,550) =4.13, p<.05. Male students (Mean=3.00, SD=0.39) also showed significant higher interest in science careers than did female students (Mean=2.88, SD=0.37), F (1, 541) =5.10, p<.05.

Additionally, the results showed that there was a significant difference on the students content knowledge tests, F (1, 510) =8.13, p=0.005. A further analysis showed that there is a significant difference on students content knowledge among different teachers, F (4, 369) =7.94, p<.001, effect size=0.81, power=.99. Table 2 shows overall students content knowledge test scores by teachers. Teacher B and F students showed significant higher students test results than Teachers A, C, D, and E after the live simulation. Furthermore, the Pearson test revealed significant correlation resided between teachers' content knowledge covered on students' content knowledge tests and attitudes toward science. Specifically, teachers who covered most of science vocabulary thoroughly in class or through homework had major impact on students' content knowledge and positive attitudes toward science.

Table 1. Descriptive Statistics of Students' TOSRA Before and After the Live Simulation

	0-pre/ 1-post	N	Mean	Std. Deviation
Social implications of science	0	279	3.09	0.46
	1	287	3.09	0.43
Normality of scientists*	0	277	3.14	0.40
	1	282	3.22	0.38
Attitude toward scientific inquiry	0	283	3.20	0.46
	1	286	3.18	0.44
Adoption of scientific attitudes	0	279	3.03	0.43
	1	288	3.05	0.41
Enjoyment of science lessons	0	275	2.93	0.48
	1	284	2.92	0.42
Leisure interest in science	0	270	3.05	0.50
	1	281	3.00	0.45
Career interest in science	0	273	2.91	0.38
	1	285	2.92	0.38

*p<.05

Table 2. Descriptive Statistics of Students' Content Knowledge Tests Before and After the Live Simulation by Teachers

Teachers	0-pre/ 1-post	N (of Students)	Mean	Std. Deviation
A	0	21	11.57	4.59
	1	19	11.58	2.67
B*	0	14	11.86	3.98
	1	12	15.75	4.05
C	0	51	10.14	2.69
	1	38	10.61	3.23
D	0	77	10.51	3.05
	1	91	13.99	2.51
E	0	22	11.92	3.44
	1	24	12.05	4.13
F*	0	24	10.98	3.79
	1	21	15.46	2.14
G	0	27	11.49	4.07
	1	25	12.36	2.36

*p<.05

Discussion/Implications

The usefulness of technology simulation as a method for learning has been applied sporadically within education. This study supports the significant role of simulation in transmission of knowledge for educational purposes. We found that participation in the live simulation may have influenced students' attitude toward science over time. Students' normality of scientists was one of the science-related attitudes that showed significant change. This result is confirmed by prior research into realistic simulations showing the relevance of science and change in how students perceive scientists (Jarvis & Pell, 2005). This has significant implication for promoting STEM-related career awareness. As the nation strives to increase students' knowledge of STEM-related careers, the live simulation learning environment has potential for changing students' self-perception and goal orientation. Such high-tech, computer-assisted cooperative simulation of a real-life situation helped to trigger application learning as well as professional identity/awareness/interest/construction.

Additionally, we found there is a difference in gender toward science attitudes and interest in science careers. Boys tended to be more adoptable and receptive to the notion of science attitudes, such as discovering new things, and more interest in careers toward science. Gender has been characterized as the most significant variable towards students' attitude to science (Gardner, 1975). Previous research has shown that boys have a consistently more positive attitude to school science than girls (Becker, 1989; Breakwell & Beardsell, 1992; Hendley, Stables, & Stables, 1996; Weinburgh, 1995). With regards to the career choices, Whitehead (1996) discussed gender stereotype may influence career choices. For example, boys are more likely to choose sex-stereotype careers than girls. Despite of gender stereotype, the findings of this study showed that the live simulation may have increased boys' interests in science or science careers. Therefore, future research should continue to study how the instructional content or technology-enhanced learning environment will lead to a significant increase in the choices of science-related careers by girls.

We also recognized that the potential gain depends on the quality of teacher preparation as well as teacher's instructional strategy. From this study, we learn that teachers who spent more time on science vocabulary had impacted students' content knowledge and attitudes toward science. Such support seems to build up students' knowledge about the subject matter and support self-confidence so that students can participate effectively and make real gains in the complex simulated learning environment. The study reaffirms the value of a synergy between effective teaching practice and use of simulation in optimizing students' learning of science.

Future Research

Our next step is to extend current findings by conducting an experimental study comparing students who experience live simulation to those who do not. We also can further our research on the live simulation by investigating what kinds of teaching strategies (e.g., coaching, inquiry, or mentoring) best align with a simulated learning environment.

Note

An earlier version of this article was presented at the 2008 annual meeting of the American Educational Research Association in New York. We thank the Challenger Learning Center at Wheeling, WV for their support of data collection, and teachers and students who participated in the simulation and the study.

References

Becker, B. J. (1989). Gender and science achievement: a re-analysis of studies from two metaanalyses. *Journal of Research in Science Teaching, 26*, 141-169.

Bell, P. (2002). Using argument map representations to make thinking visible for individuals and groups. In T. Koschmann, R. Hall & N. Miyake (Eds.), *CSCL 2: Carrying forward the conversation.* (Vol. 2, pp. 449-505). Mahwah, NJ: Lawrence Erlbaum Associates.

Boyle, B., Lamprianou, I., & Boyle, T. (2005). A longitudinal study of teacher change: What makes professional development effective. *School Effectiveness & School Improvement, 16*(1), 1-27.

Breakwell, G. M., & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science, 1*, 183-197.

Cognition and Technology Group at Vanderbilt (1993). Anchored instruction and situated cognition revisited. *Educational Technology*, 52-71.

Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching*. NY: National Commission on Teaching and America's Future.

Davis, E. A., & Linn, M. C. (2000). Scaffolding students' knowledge integration: prompts for reflection in KIE. *International Journal of Science Education, 22*(8), 819-837.

Fraser, B., J. (1978). Development of a test of science-related attitudes. *Science Education, 62*(4), 509-515.

Gardner, P. L. (1975). Attitudes to science. *Studies in Science Education, 2*, 1-41.

Haladyna, T., Olsen, R., & Shaughnessy, J. (1982). Relation of student, teacher, and learning environment variables to attitudes toward science. *Science Education, 66*(5), 671-687.

Hardre, P., & Chen, C. H. (2005). A case study analysis of the role of instructional design in the development of teaching expertise. *Performance Improvement Quarterly, 18*(1), 34-58.

Hendley, D., Stables, S., & Stables, A. (1996). Pupils' subject preferences at Key Stage 3 in South Wales. *Educational Studies, 22*, 177-187.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the twenty-first century. *Review of Educational Research, 70*(2), 151-179.

Hsu, Y.-S., & Thomas, R. A. (2002). The impacts of a web-aided instructional simulation on science learning. *International Journal of Science Education, 24*(9), 955-979.

Jarvis, T., & Pell, A. (2005). *Secondary pupils of different abilities response to an e-Mission simulation of the Montserrat volcanic eruption.* Paper presented at the American Education Research Association, Montreal, CA.

Jonassen, D. H. (2003). Using cognitive tools to represent problems. *Journal of Research on Technology in Education, 35*(3), 362-379.

Jonassen, D. H., & Reeves, T. C. (1996). Learning with technology: using computers as cognitive tools. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 693-719). New York: Macmillan.

Kim, B., & Reeves, T. C. (2007). Reframing research on learning with technology: In search of the meaning of cognitive tools. *Instructional Science, 35*(3), 207-256.

Klopfer, B. J. (1971). Evaluation of learning in science. In B. S. Bloom, J. T. Hastings & G. F. Madaus (Eds.), *Handbook on summative and formative evaluation of student learning*. New York: McGraw-Hill.

Lee, V. E., & Burkam, D. T. (1996). Gender differences in middle grade science achievement: Subject domain, ability Level, and course emphasis. . *Science Education, 80*(6), 613-650.

Lewis, E., Stern, J., & Linn, M. (1993). The effect of computer simulations on introductory thermodynamics understanding. *Educational Technology, Jan.* , 45-58.

Linn, M. C. (1995). Designing computer learning environments for engineering and computer science: The scaffolded knowledge integration framework. *Journal of Science Education and Technology, 4*(2), 103-126.

Linn, M. C. (2000). Designing the knowledge integration environment. *International Journal of Science Education, 22*(8), 781-796.

Linn, M. C., Clark, D., & Slotta, J. D. (2003). WISE design for knowledge integration. *Science Education, 87*(4), 517-538.

Linn, M. C., & Hsi, S. (2000). *Computers, teachers, peers: Science learning partners.* Mahwah, NJ: Lawrence Erlbaum Associates.

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review, 19*(309-326).

Myers, R. E., & Fouts, J. T. (1992). A cluster analysis of high school science classroom environments and attitude toward science. *Journal of Research in Science Teaching, 29*(9), 929-937.

Osborne, J., & Simon, S. (1996). Primary science: past and future directions. *Studies in Science Education, 26*, 99-147.

Osborne, J., Simon, S., & Collin, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079.

Papanastasiou, E. C., & Zembylas, M. (2004). Differential effects of science attitudes and science achievement in Australia, Cyprus, and the USA. *International Journal of Science Education, 26*(3), 259-280.

Simpson, R. D., & Oliver, J. S. (1990). A summary of major influences on attitude toward science and achievement in science among adolescent students. *Science Education, 74*(1), 1-18.

Spinello, E. F., & Fischbach, R. (2004). Problem-based learning in public health instruction: A pilot study of an online simulation as a problem-based learning approach. *Education for Health, 17*(3), 365-373.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: a meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching, 32*, 387-398.

Weller, J. M. (2004). Simulation in undergraduate medical education: Bridging the gap between theory and practice. *Medical Education, 38*, 32-38.

Whitehead, J. M. (1996). Sex stereotypes, gender identity and subject choice at A level. *Educational Research, 38*, 147-160.