

Does the Use of a Weather Forecasting Computer Simulation Program Increase Student Understanding of Specific Weather Concepts?

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Abstract

This study considered the use of a weather simulation game (edheads.org) on student understanding of weather concepts with the goal of informing classroom instruction. Seventh grade students in one Philadelphia middle school were taught weather concepts following the prescribed curriculum. One section of students also used an approved weather forecasting simulation game for one class period. Both groups of students were assessed before and after the lesson. Those students who participated in the weather simulation also completed written reflections of their experience. Those students exposed to the weather simulation scored slightly better on all focus questions, including an open-ended response, and showed a greater amount of growth.

Background

While attending the University of Pennsylvania during the spring of 2006, I was introduced to a science website (learningscience.org) that compiled interactive sites and simulations for use in the science classroom. All sites were evaluated and approved by a board of active science teachers. On a whim, I let my students play around on one of the sites that connected to our study of weather at the time. The students performed better than others on the next test. I wondered if it was a result of this experience. This action research paper provided a chance to test my hypothesis. Does the use of an approved computer simulation game increase student understanding of weather concepts?

Weather and climate is a main focus of the seventh grade science curriculum in Philadelphia. Students explore the atmosphere, wind and weather patterns and forecasting throughout the winter months. An interactive website, www.edheads.org/weather, allows students to act as weather forecasters and predict the movement of fronts across the United States. Students start out with simple actions and move through higher levels of difficulty. The knowledge required to be successful on the game is tied to the standards and objectives of the prescribed weather unit. To test the effectiveness of the computer simulation experience, students needed to be exposed to it during the time period in which they were learning about weather patterns and forecasting methods.

This study was conducted with a heterogeneous group of Philadelphia seventh graders. AMY-Northwest Middle School is a small, public middle school serving approximately 240 sixth to eighth graders throughout the city of Philadelphia. The seventh grade students are divided into three heterogeneous sections, each with about 30 students. Due to trips, testing pull-outs and student absences, approximately 20 students per section participated in the study. This study focuses on the work of two of these sections. The demographics of each section can be seen in the chart below:

| | Section A | Section B |
|--|-----------|-----------|
| Total Number of Students | 19 | 20 |
| Male | 9 | 7 |
| Female | 10 | 13 |
| IEP students (either currently classified or in the process of being evaluated for academic/behavioral concerns) | 3 | 2 |
| Mentally Gifted Students | 2 | 5 |
| African-American | 16 | 18 |
| Caucasian | 2 | 2 |
| Hispanic | 1 | 0 |

Both classes have performed comparably on class and standardized assessments thus far. Both groups of students receive science instruction daily in the same science classroom. These classes were selected because of scheduling reasons. All students and families were told their work would be part of a study, and were given the option to not participate. For the purpose of the study, each student was assigned a number. This number will be used during data collection, rather than the student name, so as to protect participant privacy and confidentiality.

If there is a significant difference between the performances of those students who were exposed to the simulation and those who were not, it could affect my methods of instruction. I would push to ensure students have the opportunity to experience the simulation as part of the curriculum, and be more likely to include similar experiences for other areas of study.

Literature Review

The use of technology in today's classroom is no longer an anomaly. A walk through the halls of most schools will take one past classrooms filled with computers. An observer might see students working together on slideshow presentations, typing reports or watching a demonstration on the interactive Smartboard. The benchmarks for science literacy, as well as the National Science Education Standards, incorporate use and understanding of technology into student requirements for proficiency (Benchmarks, 1993). The ever-increasing technological opportunities allow teachers today to teach in a way that was once hard to imagine – but how does this technology affect student understanding?

There is a general consensus among researchers about the advantages of technology, especially in science. Technology in science offers benefits for inquiry-based learning, “providing support for communication and expression and the ability to present interaction with information in a variety of formats” (Edelson 1999). In an

evaluation of technology use in project-based learning, one group of researchers named six contributions that technology can make to the learning process:

- (1) providing access to information
- (2) allowing active, manipulable representations
- (3) enhancing interest and motivations
- (4) diagnosing and correcting errors
- (5) structuring the process with tactical and strategic support
- (6) managing complexity and aiding production (Blumenfeld et al 1994).

Studies focusing on computer simulations echo these sentiments. Hyunjeong Lee and fellow researchers defined computer simulations as “interactive software programs in which individuals explore new situations and complex relationships of dynamic variables that model real life” (Lee 2006). Computer simulations address many of the factors recognized as influencing student attitudes in science, such as motivation, cooperative learning, hands-on activities and student involvement in learning (Zacharias 2003). Through simulations, students are given responsibility over their own learning and are provided with an interactive learning experience, allowing them to visualize problems and solutions (Zacharias 2003). In addition to positively influencing student attitudes toward science, simulations can aid in students’ understanding of abstract concepts. “Because of their ability to present dynamic information and to visualize complex concepts, simulations are among those types of computer applications that educators view as especially promising for the learning of complex scenarios, problem-solving tasks, and the study of phenomena that are not visible to the human eye” (Lee 2006).

While the amount of research studies on use of technology in education is astounding, current research into computer simulations in science is tailored to specific programs and disciplines. A review of recent studies of computer simulation use shows cautious optimism and unlimited potential. Researcher Jeremy Roschelle and his colleagues compiled a number of isolated computer simulation studies from individual classrooms and schools, using these studies to inform their work about how student learning is changing as a result of computer-based technologies. The researchers once again addressed the similarities between what has been proven successful in traditional instruction (immediate feedback, high student engagement, connections to real-world contexts) and what is provided through computer simulations (Roschelle 2000). Most involved with education reform agree that students should be actively engaged in the learning progress, and new curricula holds students accountable for analyzing information, communicating effectively and designing solutions. Roschelle argues that computer-based technologies are extremely useful for this type of learning, pointing to the use of science program “Microcomputer-Based Laboratory” which allows students to instantaneously graph data and see the results of their experiment. Rather than spend time gathering data and plotting points on a graph, students can immediately start interpreting their results (Roschelle 2000).

Computer simulations also allow for immediate feedback and interaction, something that is not always possible in the traditional classroom setting. Roschelle points out three ways computer simulations support the need for feedback: (1) providing immediate feedback and interaction for students, (2) engaging students so the teacher can

work with other students (3) analyzing student performance and providing targeted instruction (Roschelle 2000).

Simulations are now being used in science classes to help students understand scientific concepts, not simply how to solve a calculation. Research shows that simulations, especially the visualization and interactions involved, have helped students grasp more abstract and complex concepts (Gordin 1994).

The computer simulation used in this study, www.edheads.org/weather, includes many of the characteristics mentioned above. The simulation focuses on weather prediction and forecasting, and is geared toward fourth through ninth grade students. Students take on the role of a weather forecaster, interpreting weather data to make predictions. Aligned with national science standards, the program guides students through increasingly difficult levels and addresses real-world concepts. The simulation is in the form of a game, providing motivation for those who need it. Students are actively engaged in the entire process. The simulation also provides immediate feedback to students after each prediction, and includes the option of printable score sheets for teacher and student use.

In addition to meeting most characteristics of an effective simulation, the edheads.org weather site addresses some common student misconceptions about weather in a real-world format. A 2002 review of student ideas about weather revealed that weather concepts are often taught only in science, when in reality the topic requires a broader understanding of geography (Henriques 2002). This study also highlights student misconceptions in a variety of areas, including confusion about weather map symbols. These misconceptions are addressed within the edheads.org simulation as students must interpret weather symbols and apply their understanding to succeed at the game.

As use of computer simulations in science increases, so will the amount of research on the subject. Already, some researchers are evaluating the visual presentation of simulations, trying to determine if there is an optimal load for maximum student understanding (Lee 2006). Nearly all studies focused on technology and computer simulation stress the importance of providing professional development for teachers, yet they also include a similar underlying theme – if used effectively, technology and simulations can provide learning opportunities that are unmatched in the traditional classroom.

Methodology

Research Question: Does the use of a weather forecasting computer simulation program increase student understanding of specific weather concepts?

The testing period of this study took place over four 45-minute class sessions. During the first session, both sections took a pre-assessment. This pre-assessment was comprised of 10 factual questions and one open-ended question. The questions ranged in difficulty from very easy to challenging. The factual questions were taken directly from the website's assessment, while the open-ended question was taken from a practice standardized test question provided through the curriculum. All questions pertained to weather concepts connected to the seventh grade standards. Students had 20 minutes to

complete this assessment. The open-ended question was scored using a rubric (see Appendix).

During the second class session, students received traditional instruction as per the school district curriculum. Both sections completed the textbook activities, taking notes and answering questions about weather patterns, fronts and high and low pressure systems. Section A students also spent an additional class period in the computer lab playing the computer simulation. Students were given a short introduction to the simulation and had 45 minutes to play the game. As they played the game, the teacher-researcher circulated the room, recording comments and questions while monitoring student engagement. While the students in Section A spent their class period in the computer lab, Section B students completed a directed reading sheet as dictated by the core curriculum.

During the final class session, students took a post-assessment. This assessment was identical to the pre-assessment administered before the start of the study. The students exposed to the computer simulation also wrote a reflection based upon their experiences. This allowed the teacher-researcher to collect positive or negative feedback from the students about the experience.

Student assessments were analyzed on an individual and class basis. Results were recorded in chart form, allowing for a comparison between individual questions, students, classes and pre- and post-tests. Student answers for all factual questions were recorded for both pre- and post-tests to allow for an analysis of each question and its common responses. The open-ended question was assessed using a 3-point rubric on both the pre- and post-tests. Individual student post-tests were compared to their pre-tests to note if there was any measurable difference in performance. Section A student post-test scores were also compared to Section B student post-test scores to determine the effect (if any) of the computer simulation experience.

Data

Findings

A data analysis of pre- and post-assessments for both sections shows similar performance by both groups of students, with Section A students performing slightly better on all questions and showing slightly more growth from pre-assessment to the post-assessment.

The majority of students performed very well on the pre-assessment, a performance that can be attributed both to prior knowledge as well as relative ease of some questions. Despite this, it is still possible to evaluate growth and understanding by focusing on certain topics and questions. I chose to focus my analysis on questions 2, 6, 7, 9 and the open-ended response.

Question 2 focused on front movement. While a number of students did choose the correct answer (west to east), there were a number of students who chose incorrectly on the pre-assessment. When taking the post-assessment, 100 percent of the students in Section A answered this question correctly. In Section B, three students still did not show understanding of front direction.

Questions 6 and 7 focused on high and low pressure systems. Student answers were varied on the pre-assessment; within section A, 79 percent of students chose an incorrect answer when asked what happens as a result of a high pressure system. Sixty-eight percent of students chose incorrectly when asked about a low pressure system. Section B had a similar amount of incorrect answers; 50 percent were wrong about high pressure systems, while 65 percent chose incorrectly about low pressure systems.

The post-test showed improvement for Section A students. While only 4 students were correct on the pre-test, 11 students had the correct answer on the post-test when asked about high pressure systems. Six students answered correctly about low pressure systems on the pre-test; this number increased to ten on the post-test.

The post-test results for Section B on questions 6 and 7 showed little improvement from the pre-test performance. The number of correct answers for the high pressure system questions stayed the same, while two additional students answered correctly about low pressure systems than had on the pre-test.

Question 9 again focused on front movement, this time asking how to calculate how far a warm or cold front would move in a particular amount of time. This question showed a noticeable difference between the two sections. Within section A, 15 out of 19 students answered incorrectly on the pre-test. On the post-test, 15 out of 19 students answered correctly; this was a significant improvement. In section B, 17 out of 20 students answered incorrectly on the pre-test. There was little improvement on the post-test; 15 out of 20 students still chose the incorrect answer.

The open-ended response, taken directly from a PSSA practice question, asked students to combine knowledge about how fronts move and what weather results from a high pressure system. Students could score from a 0 (no answer or completely off topic) to a three (answered all parts of the question correctly and provided logical explanation). Students in both sections struggled with this question on the pre-test. In Section A, nearly half of the students received a 0 for the question; only four of the 19 students (21%) scored either a two or a three. When the students took the post-test, only two students scored a 0. Fifteen of the 19 students (79%) scored a two or a three. In Section B, seven students scored a 0 on the pre-test, and five students still scored a 0 on the post-test. Five students out of 20 (25%) scored a two or a three on the post-test; this number rose to 11 out of 20 (55%) on the post-test.

Data analysis reveals that both groups showed improvement from the pre-test to the post-test. Section A had a higher percentage of students showing improvement (84%) than Section B (55%) on the factual questions. Section A also had a higher percentage of students showing improvement (74%) on the open-ended response than students in Section B (45%).

In addition to student pre- and post-assessment scores, all students who engaged in the weather forecasting simulation were asked to write a reflection of their experience. Student responses were coded as positive, negative or neutral. Of the 19 students in Section A, three students wrote negative reflections about the experience. These students called the game “hard,” said “it was frustrating because I had to read to figure out the answer,” and “I learn better when I’m taught by [the teacher].” Five students wrote

reflections that included both negative and positive comments. The remaining eleven students wrote positive reflections about their experiences. Some comments included:

“It made me want to ask more question about [weather].”

“I would use the game again because it helped me understand how weather worked.”

“I was having fun ... I felt like I was learning new stuff.”

“It helped me understand the way high and low pressure systems worked.”

It is interesting to note that the two students in Section A who scored perfect scores on both parts of the post-assessment (Students A3 and A14) did not share the same opinion of the activity. Student A3 wrote a brief reflection, stating, “It was fun and I would like to do it again.” Student A14 wrote a lengthy reflection about how he did not like the computer simulation and preferred to be taught by a teacher. “I was getting really frustrated,” he wrote. “I like it better when you teach me since I will understand it more since if I have a question you can come and explain it in words that I will understand.”

Conclusion

This study showed that for this specific population, the use of a computer simulation did positively impact student performance and understanding. Section A students showed a higher level of performance on the topics in question overall. This seems to follow with the current research, which states that appropriate technology can enhance student understanding by providing visual application and simulation of science concepts. However, it is important to note the limitations of this study when considering its implications for the classroom.

This study focused on one specific website (www.edheads.org) and should not be considered proof for incorporating technology in the classroom. Rather, the results should be reflective of this simulation only. In addition, this study involved only 39 students, a small sample size.

Several factors could have influenced the results of this study and warrant consideration. The pre-assessment given was a combination of the web site assessment and a curriculum standardized test question, and students scored correctly on most of the factual questions. While it was possible to still evaluate student performance and growth by focusing on five specific questions (four factual questions and the open-ended response), the pre-assessment should be considered an area that needs improvement in the future. Using the results of this study, it would be possible to craft a more tailored pre-assessment that focuses on proven areas of weakness.

The time constraint of the required curriculum and class time was also a factor. This study was restricted to a maximum of four class sessions during the week of January 22, as this was the window for air masses, fronts and weather forecasting in the curriculum. While my administrator was supportive of my study, it was understood that I would not fall behind in the prescribed science curriculum. This time constraint added pressure and meant there was no time for a “re-do.”

When conducting classroom research, there are inevitably outside factors that cannot be controlled. There was a violent fight between two students (not involved in the study) during the lunch period before Section A took its post-assessment. As the students were testing, the principal walked in to address the situation and spoke for several

minutes. It is possible that this event affected student performance. The effect of these outside influences is difficult to quantify. It is important that they are taken into consideration, however, when reviewing the results of the study and determining its validity.

This study holds different implications for my own science classroom and teaching practices and the larger teaching community. This was a focused, small study with a select group of students. As an outside educator, I would appreciate this study but consider the limitations and outside factors involved before accepting its validity and using it to influence my instructional choices. As the teacher-researcher involved, however, I have a different view of its implication. Based on my experiences and the data that I gathered from this action research project, I will continue to make time for my students to experience the edheads.org weather simulation. As a teacher who is constantly looking for ways to engage students in science and motivate them to learn, I was struck by the comments I heard while circulating the computer lab (see appendix). These questions and comments, some by notoriously apathetic students, showed me students were engaged. This high level of engagement, coupled with the supporting quantitative data from this study, is the reason why I will continue to use this weather simulation.

Works Cited

American Association for the Advancement of Science. Benchmarks for Science Literacy. New York: Oxford University Press, 1993.

Blumenfeld, P., et al. "Motivating Project-based Learning" *Educational Psychologist* 26 (1994).

Edelson, D. et al. "Addressing the Challenges of Inquiry-Based Learning Through Technology and Curriculum Design." *Journal of the Learning Sciences* 8.3, (1999): 391 – 451.

"Edheads – Activate Your Mind!" Weather Teacher's Guide.
www.edheads.org/activities/weather/teacher.htm

Gordin, D., and Pea, R. "Prospects for scientific visualization as an educational technology." *The Journal of the Learning Sciences* 4, (1995): 249-79.

Henriques, Laura. "Children's ideas about weather: a review of the literature." *School Science and Mathematics* 102.5, (2002): 202-216.

Lee, Hyunjeong et al. "Optimizing Cognitive Load for Learning From Computer-Based Science Simulations." *Journal of Educational Psychology* 98.4, (2006): 902-913.

Roschelle, J. et al. "Changing How and What Children Learn in School with Computer-based Technologies." *The Future of Children* 10.2, Children and Computer

Technology (2000): 76-101.

Zacharias, Zacharia. "Beliefs, Attitudes and Intentions of Science Teachers Regarding the Educational Use of Computer Simulations and Inquiry-Based Experiments in Physics." *Journal of Research in Science Teaching* 40.8, (2003): 792-823.