Integrating Simulations in Teaching of Science Argumentation

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Abstract: In this study, we integrated computer simulations into Lawson's hypothetico-deductive argumentation, with an intention to promote students' argumentation skills and understanding of scientific concepts. By using action research methodology, two teaching cycles were conducted in a 9th grade science classroom with thirty-six students. Learners' argumentation skills and understanding of science concepts were evaluated through two exams. Results showed that the integration of computer simulation in argumentation assisted the development of some argumentation skills and scientific concepts. In the parts of "variable selection" and "conclusion making," the data revealed significant differences between the pretests and posttests. The study also showed significant improvements in science concepts during the second teaching cycle. At the end, this research study provides suggestions for teaching of argumentation with computer simulation and suggestions for future studies.

Keywords: Simulation, Argumentation, Scientific Concepts

Introduction

Computer simulations have been used in science teaching for many years. Simulations can stimulate students' interests by providing dynamic representations [1] and flexible operations on the computer. Several characteristics of simulations correspond with argumentation, including reducing the complexity of experiments [2], supplying experience of the processes of hypothetico-deductive argumentation [3], and providing immediate feedbacks on tests of causal relationships [4]. Studies on how simulation integrated into argumentation influence students' scientific learning is still not well documented in literature. Hence, the study combined simulation with argumentation to help students learning abstract scientific subjects. The present study was designed to address the following research questions: (1) What challenges and difficulties did researchers encounter in integrating simulations into teaching science argumentation? How did they manage to solve the problems? (2) To what extent did integrating simulations into science argumentation influence students' development of argumentation skills? (3) To what extent did integrating simulations into science argumentation effect students' understanding of scientific concepts?

1. Methods

In this study, we employed action research methods. We integrated simulations in scientific argumentation to teach the topics of *conservation of energy* and *electric power* during the two teaching cycles.

1.1 Sample

The research subjects in the study included 36 ninth grade students. Eighteen of the students are female. All students were evenly into six teams during the intervention.

1.2 Instruments

1.2.1 Exams of Argumentation Skills

Two exams for assessing students' argumentation skills were designed for the two topics by following the process of Lawson's hypothetico-deductive argumentation [5]. Each exam includes five parts, and each part measures one argumentation skill. The five parts are: *hypothesis generating, planning test, predicting results, observing results of tests, and conclusion making*. Students completed the exams at the beginning and the end of each teaching cycle.

1.2.2 Exams of Scientific Concepts

In the first teaching cycle, the researcher designed a 20-item test of scientific concepts for the topic *conservation of energy*. This exam covers the following concepts: friction, symmetry of track, change of kinetic energy, positions and mass. The Cronbach alpha reliability coefficient on the first exam was .851, and the difficulty indexes of 20 problems were between .40 and .80. In the second teaching cycle, another 20-problem exam of electric power was designed with another five conceptions, including properties of wire, voltage, resistance, circuit arrangement, and current. Its Cronbach alpha reliability coefficient was .752, and its difficulty indexes were between .40 and .80. Students took the exams both at the beginning and at the end of each teaching cycle.

1.3 Other data collection

Other data included researchers' teaching reflections, video recording of the classes, and students' interviews.

1.4 Treatment and Procedure

In this study, the researcher adopted Lawson's hypothetico-deductive argument to design two teaching cycles by integrating simulations in teaching of science argumentation. Throughout the instructional treatment, students worked in small groups and selected their hypotheses for the driving question of the topic. They tested out the hypotheses in the simulations by manipulating different parameters. Students collected data on the computer and recorded evidence that either supported or rejected their hypotheses. At the end of the teaching cycle, the whole class discussed, through accepting and rejecting different hypotheses, the relationships between variables and the observed phenomena.

1.5 Data Analyses

We used paired-samples t-test to analyze change of argumentation skills and change of understanding of scientific concepts. Other qualitative data were categorized.

2. Results

2.1 Improvement of Argumentation Skills in Two Teaching Cycles

The results of t-test in the first teaching cycle showed there were significant differences between pretest and posttest in variable selection ($t = -2.080$, $p<0.05$). The variable selection is a part of the argumentation skill, planning test. The researcher reasoned that the 9th grade students had been familiar with control of variables since 7th grade. So they could more easily master this skill. Furthermore, the results in the second teaching cycle showed there were significant differences in conclusion making ($t = -2.074$, $p<0.05$). This means integrating simulations in teaching of science argumentation could help to promote students' skill of conclusion making.

2.2 Understanding of Scientific Concepts

In the second teaching cycle, the study added discussion after the instruction. Each experiment team needed to discuss how each variable could influence the results, and had to share their opinions with other teams. And the results of t-test showed there were significant differences between pretest and posttest in all five scientific conceptions (i.e., properties of wire: $t = -6.453$, $p<0.01$; voltage: $t = -8.384$, $p<0.01$; resistance: $t = -8.688$, $p<0.01$; circuit arrangement: $t = -8.353$, $p<0.01$; current: $t = -8.327$, $p<0.01$).This means the intervention combining with discussion helped students understand all concepts related to the topic.

2.3 The Difficulties Occurred during Instruction and Suggested Solutions

Teaching with simulation is very different from traditional instruction. Table 1 shows examples of the teaching difficulties and challenges encountered by the instructor (the first author) and the corresponding solutions.

Table 1. Difficulties occurred during instruction and suggested solutions

Teaching Cycle	Challenge and Difficulties	Suggested Solution and Teaching Strategies	Results
The First Cycle	Students did not know what to observe in the computer simulations	Provide both computer simulation and video of demonstrating the experiment	In the second cycle, students could better associate the phenomenon with simulation
	Students could not report the data completely and clearly. As a result, students had difficult draw conclusions from the data.	Encouraging students to take screen shots of the simulations and use them to write detailed explanations of the results	In the second cycle, students could explain the data directly with the screen shots
The Second Cycle	Students had difficulty using the simulation to conduct the experiment of electric power	Teacher demonstrated and practiced with students to let students know how to manipulate the different parameters and the virtual equipment	In the second test of the hypothesis, students viewed the use of simulations as actual experiment operation
	Students could not understand the functions of	Design a new table (shown in Table 1)for students to record	This may contribute to the better understanding of scientific

	the virtual equipment and their relationships to data collected. Hence, students had difficulty show their plans of testing hypotheses.	the use of virtual equipment	concepts during the second teaching cycle

Figure 1. New Table of Using Experiment Equipments

The name of equipment	The state of equipment (Fill in with relevent data. ex. voltage, resistance, current...etc.)	Quantity

3. Discussion

The study illustrated how students developed argumentation skills, increased their desire for exploring scientific methods, determined with objectives and reasons of conducting science experiments, understood how scientists built up their understanding through argumentation, and learned with scientific concepts s. This study also suggests that instructors pay a careful attention to students' basic abilities in both using computer skills and argumentation skills prior to implementing instruction. Students' computer abilities related to the instruction refer to typing skills, taking screen shots, searching with Internet, and using emails. As for argumentation, students need be familiar with presenting their results and arguments both literally and logically. Since the study is limited by its implementation in physics and its 9^{th} graders as only participants, future studies may consider to implement similar instructions for other science subjects or in different grades.

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