A Study of Developing Students’ Scientific Argumentation Skills in a Computer-assisted Project-based Learning Environment

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Abstract: The purpose of this quasi-experimental study was to explore how 111 7th graders in the United States developed argumentation skills and science knowledge in a graph-based computer-assisted project-based learning environment. Verbal collaborative argumentation was recorded and the students’ post essays were collected. A random effects ANOVA was conducted and a significant difference in science knowledge about alternative energies between conditions was observed. A MANOVA was conducted and there was a significant difference in counterargument and rebuttal skills between conditions. A qualitative analysis was conducted to examine how the graph-based, computer-assisted program supported students’ development of argumentation skills and affected quality of collaborative argumentation. The findings indicated that with the graph-based computer-assisted program, the quality scores of collaborative argumentation were high and consistent. The difference in argumentation structure and quality of argumentation between conditions might explain a difference in science knowledge as well counterargument and rebuttal skills (argumentation) between both conditions.

Keywords: argumentation, graph-based computer-assisted program, project-based learning

Introduction

The Next Generation Science Standards (NGSS) (National Research Council, 2012) identified “engaging in argument from evidence” (p. 12) as one of the essential eight science practices for students in the United States. As a common practice for scientists, argumentation is a process for constructing explanations and identifying solutions. A number of researchers (Kuhn, 1993) have defined essential elements of argumentation: position, reason, evidence, counterargument, and rebuttal. A position refers to an opinion or conclusion on the main question that is supported by reason. Evidence is a separate idea or example that supports reason or counterargument/rebuttal. Counterargument refers to an assertion that counters another position or gives an opposing reason. A rebuttal is an assertion that refutes a counterargument by demonstrating that the counterargument is not valid, lacks as much force or correctness as the original argument, or is based on a false assumption.

Recent studies (Scheuer, Loll, Pinkwart, & McLaren, 2010) have explored the potential of graph-based computer programs in improving learning outcomes and facilitating cognitive processes. The present study addresses the limitations of existing research (Dwyer, Hogan, & Stewart, 2012) on graph-based computer programs by engaging students in a project-based learning environment that involves using a computer-assisted program to support collaborative argumentation. The purpose of the study was to explore the impact of the learning environment on the development of middle school students’ science knowledge and argumentation skills in a suburban school in the United States. The following research questions were addressed:

1. What is the difference in science knowledge between students in a graph-based computer-assisted project-based learning environment (treatment condition) and students in a project-based learning environment without such a computer-assisted program (control condition)?
2. What are the differences in argumentation skills (as measured by reason, evidence, counterargument, and rebuttal) between students in a graph-based computer-assisted project-based learning environment and students in a project-based learning environment without such a computer-assisted program?
3. How does a graph-based, computer-assisted program support students’ development of argumentation skills?
4. How does a graph-based, computer-assisted program affect the quality of collaborative argumentation between the conditions?
Literature review
With the general positive impact on argumentation skills, the previous studies all involved students in active construction of content knowledge in an authentic problem (e.g., public policy, law) and collaborative argumentation, which reflects the critical elements of project-based learning (Fogleman, McNeill, & Krajcik, 2011). Thus, in the present study, project-based learning was used to develop argumentation curriculum and is discussed. Moreover, with the advance of technology, numerous researchers (Moursund, 2003) have proposed to add technology to augment the effectiveness of a project-based learning environment. Thus, this study examined the role of a graph-based, computer-assisted program in supporting collaborative argumentation process in project-based learning environment.

Methods
A total of 54 students comprised the treatment condition while a total of 57 students were in the control condition. In the treatment condition, the students worked in teams of three to five. Each team in the treatment condition was engaged in verbal collaborative argumentation and argued with other teams using the graph-based computer-assisted program. In both conditions, verbal collaborative argumentation was recorded with a digital camcorder. After one week, the students in both conditions were asked to write post essays. The topic was, “If the US could fund only one form of alternative energy, which one should you select?”

Findings
To address RQ 1, results indicated that the treatment group scored significantly higher in science knowledge than the control group, $F(1, 3.66) = 8.45, p = .049$, with a standardized group mean difference of $d = 0.68$, which corresponded to a large effect size. To address RQ 2, results of the MANOVA showed a statistically significant group difference on the four dependent variables considered simultaneously, $A = 0.86, F(4, 109) = 4.50, p = .002$. The canonical correlation between the treatment condition and the dependent variables was .38. Follow-up univariate ANOVA comparisons, using a Bonferroni-adjusted alpha level, showed that the treatment group showed significantly higher scores than the control group on the outcomes of counterargument [$F(1, 109) = 17.29, p < .001$] and rebuttal [$F(1, 109) = 12.15, p < .001$].

To address RQ 3, in the treatment condition, four argumentation structures emerged from the analysis. 20 teams in the control condition started by supporting their selected form of energy and then argued against other forms of energy. To address RQ 4, the teams in the treatment condition demonstrating argumentation structures 1, 2 and 3 received a quality score of 5 or 6. The teams in the treatment condition that demonstrated argumentation structure 4 received a score of 3. The teams in the control condition scored from 2 to 5.

References


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