Collaborative Knowledge Building for Understanding Science Concepts

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Abstract. This study explores the effects of knowledge building on students' understanding of some science concepts. Data mainly include: (1) students' online discourse; and (2) a test with open-ended questions for assessing students' understanding of concepts pertaining to some environmental issues. Preliminary findings suggest that with support from knowledge building pedagogy and technology, students were able to work collaboratively and opportunistically with emerging ideas and to gain deeper understanding of the science concepts under study.

The students in the current study are engaged in knowledge building, in their interactions with each other, as part of an online community supported by Knowledge Forum—a computer-supported knowledge building environment—and in their work with producing and refining ideas for solving some environmental problems. Knowledge building is a social process focused on sustained production and improvement of ideas of value to a community (Scardamalia & Bereiter, 2006); and it supports an idea-centered collaboration—a non-group-based, unplanned, and opportunistic way of working with knowledge in a community (Hong, in press; Hong & Sullivan, 2009; Zhang, et al., 2009). This is different from conventional group-based teamwork in which students are often assigned defined roles for completing a holistic task by doing parts of it (Aronson & Patnoe, 1997; Slavin, 1983). Such group-based, task-driven concept of teamwork has been widely used for conventional school learning (Slavin, 1983). In the study reported below, we are interested in finding out whether introducing the alternative, idea-centered collaboration would affect students' science learning.

Method

Participants were two classes of fifth-graders from Taiwan. The control class (n=33) employed conventional instruction that highlights group learning, with each group being required to master a different sub-topic of the main topic (i.e., energy saving and carbon reduction), and then share what the learned with other groups (Aronson & Patnoe, 1997). In contrast, the experimental class (n=34) adopted knowledge building pedagogy and Knowledge Forum (KF) technology to engage students in idea-centered collaboration by working opportunistically with emerging ideas without being limited within groups. Data mainly came from notes recorded in KF and a final test on students' understanding of the main science topic studied. For the first dataset, we calculated student online activities from the first to the second stage, using midterm as a separation point, over the 18-week semester. In particular, we coded students' activities into four types of behaviors: social talk with no obvious ideas generated, idea-generating, idea-sharing, and idea-improving (Hong & Sullivan, 2009). In terms of the second dataset, the final test asked students to (1) define what energy saving and carbon reduction is, (2) explain why it is important, and (3) describe all possible ways to put it into practice. A scoring scheme was developed; students were given one point each time when a concept (for Q1) or reason (for Q2) or means (for Q3) related to energy-saving or carbon reduction was present in a student's answers. Below are three examples of student answers: "It means to waste as less energy as possible and to reduce the emission of carbon dioxide to the environment" (for Q1); "It is because conserving energy and lessoning carbon remission can slow down the greenhouse effect" (for Q2); and "To grow some plants at home" (for Q3).

Results

As Table 1 shows, there was an increasing trend (from the first to the second stage) of students' general online activities, whether they are note-creating, -reading, or -linking behaviors. Specifically for the note-linking behaviors, there is a statistically significant increase, suggesting that students spent more time working together. To further look into idea-related online activities, we identified all ideas in the database and analyzed how they were generated, shared, and refined. On average, every student generated 16.1 ideas (SD=9.77) about conserving energy or reducing carbon remission. These ideas were mostly concerned with life-styles, for example, eating (n=150), housing (n=158), and commuting (n=118). Table 2 further shows number of ideas that were shared, exchanged, and refined from the first to the second stage of the semester. Clearly, there was a trend of decreasing numbers of social talks and idea sharing (in terms of idea quantity), and that of increasing numbers of idea exchange and improvement activities (in terms of idea quality). Moreover, in terms of learning outcomes, we analyzed the final test on students' understanding of concepts related to energy saving and carbon reduction. The results showed an overall significant difference between the experimental and control groups (all questions combined, M=3.06, SD= 1.36, for the experimental group; M=2.67, SD=1.06, for the control group; t

=2.10, p =.04 <.05). In particular (Table 3) the experimental group outperformed the control group in terms of students' understanding of what energy-saving and carbon reduction is, and why it is important.

Table 1: General online activities in Knowledge Forum.

General online activities	1st stage M	1st stage SD	2nd stage M	2nd stage SD	t-test
# notes created	7.65	6.34	8.12	3.62	-0.459
# notes read	34.71	28.91	42.03	30.97	-3.455
% of notes linked	41.71%	32.30%	61.74%	29.57%	-1.128**
1. # of group notes created	2.47	1.30	3.04	2.12	0.089
2. # of build-on notes	4.78	4.28	4.15	2.64	0.441

** p<.01

Table 2: Occurrence of specific idea production and improvement related activities in Knowledge Forum.

Activity	Example	Stage 1st	Stage 2nd	t-test
Social talk	You have fewer ideas than mine. Go, go, go!!! (A22)	31	2	2.634*
Idea generation	My idea is to take more public transportation. (A03)	116	96	.952
Idea sharing	Are there other kinds of gas that cause greenhouse effect? (A16)	76	93	-.821
Idea improvement	I think your idea is good, but a better idea is to drive less. (A05)	27	94	-4.304***

** p<.01 *** p<.001

Table 3: Assessment of students' understanding of science concepts tested in this study.

	Experimental M	Experimental SD	Control M	Control SD	t-test
Concept	2.90	1.22	2.03	1.02	2.60**
Reason	2.52	1.45	1.84	0.85	2.17*
Means	3.77	1.40	4.00	1.31	-.29

* p<.05 ** p<.01

Discussion

Scientific knowledge is socially constructed (Latour & Woolgar, 1986; Merton, 1973). Yet research shows that students have little understanding of science being a social enterprise that values collaborative creation (Driver et al., 1996; Hong, in press). Instead of engaging students in conventional group-based teamwork and learning, The present study engaged students in idea-centered knowledge building. The results show that students were more likely to engage in an opportunistic way of collaboration when dealing with emerging ideas. Moreover, they were more likely to gain deeper understanding of some key science concepts under study. An important aim of the present study is to probe into the meaning of the design difference between the two types of collaboration (idea-centered vs. group-based). As such, this study was largely conducted in a naturalistic context rather than in a highly controlled experiment situation. Therefore, it remains to be further examined whether idea-centered collaboration can be truly accountable for the effectiveness observed in the present study. To this end, further interaction and discourse analyses will be conducted to fully answer the research questions.

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