S. L. Wong et al. (Eds.) (2010). Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Effects of Knowledge Building on Elementary Students' Views of Collaboration

Huang-Yao HONG[1*], Po-Hsien WANG[1], Ming HONG[2], & Ching Sing CHAI[3]
[1] *Department of Education, National Chengchi University, Taiwan*
[2] *Taipei Municipal Mu-Ja Elementary School, Taipei, Taiwan*
[3] *National Institute of Education, Nanyang Technological University, Singapore*
* hyhong@nccu.edu.tw

Abstract: This study investigates the impacts of knowledge building on students' views on collaboration. Participants were 53 fifth graders. Data mainly came from students' online activities and pre-post interview with regard to students' view on collaboration. Findings indicate that engaging students in knowledge building helped broaden students' view of collaboration, enabling them to see collaboration not just from a task-driven, group-based perspective, but also from a more idea-centered perspective.

Keywords: group collaboration, idea-centered collaboration, knowledge building

1. Introduction

A type of collaboration commonly seen and practiced during industrial age is perhaps group-based collaboration, during which the assembly-line type of production and team work have been playing an essential role in deciding how individuals work together. As such, mastery of one's own part of work in order to achieve maximum efficiency in team production is usually considered an important learning goal. Corresponding to such collaboration in industry, collaborative learning in schools is also highly group-based, during which students are often assigned a well-defined task and then asked to complete the whole task by doing parts of it based on division of labor [1]. This task-driven concept of teamwork that favors division of labor has been deeply rooted in school learning.

In contrast with group-based collaboration that favors division of labor, an alternative way of collaboration is perhaps idea-centered. Underlying such collaboration is a rationale that sees ideas as fundamental knowledge units or conceptual artifacts [2]. The ideas and theories created by knowledge workers such as scientists, engineers and architects are among the conceptual artifacts. These theories and ideas, once created, have a life of their own in that they can be improved and transformed by people who interact with them. The implication of treating ideas as basic knowledge unit in the world is that collaboration can therefore be centered on ideas, rather than based on pre-defined content of a task. Examples of such collaboration can be commonly found in research, science, technology, and business communities [3][4][5][6][7][8]. In these communities, collaboration is emergent based on need of idea improvement, rather than on division of labor. For example, new technologies are increasingly created by self-organizing knowledge workers [9] such that the open source operating system, Linux, has been developed and continues to evolve through an essentially volunteer, self-organizing community of thousands of programmers who collaborate on diversified ideas through constant exchange of open source code [3]. Putting ideas at the center around which people work collectively and interact with one another to improve these ideas thus represents an alternative view of collaboration, as well as a new opportunity for more creative learning and knowledge work [10][11][12]). To this end, the present study employed an idea-centered knowledge building approach in order to help students develop a more idea-centered view on collaboration. In brief, knowledge building is a social process with focus on the production and continual improvement of ideas of value to a community [13], and is supplemented by the use of a software program called Knowledge Forum which enables an online knowledge-building environment. Previous research suggests that the integral use of knowledge-building pedagogy and technology has been an effective means to support more interactive learning activities in class settings [14][15][16][17]. As such, it is posited that engaging students in such environments perhaps also has effects on their views of collaboration. Yet, such assumption remains to be tested, especially in the Taiwanese society. The present research thus intends to answer the following two research questions: (1) Whether engaging students in knowledge building would facilitate them to work beyond group collaboration? (2) Whether engaging students in knowledge building would help students develop a more informed view of collaboration?

2. Method

Participants and context. Participants were two classes of fifth-grade students (N=53). Most of them are from low-to-middle income families. They were sampled from a total of eight fifth-grade classes in an elementary school in Taipei. The two classes were then randomly assigned to be a control class (n=26) and an experimental class (n=27). As baseline comparison, we analyzed students' academic scores from the previous year, and no significant difference was found between the two classes ($F = .486$, $df = 52$, $p > .05$). The whole duration of the study was eighteen weeks, and they can be divided into two phases. In phase 1 (weeks one to nine), the topic of inquiry was light. For example, student studied the nature of light, how light travels, different lenses and types of eyeglasses, the relationship between light and human eyes, and light pollution. In phase 2 (weeks ten to eighteen), the topic of inquiry was sounds. For example, students studied the nature of sounds, how sounds travel, different types of sounds and music instruments, the relationships between sounds and human ears, and noise. In each week, students spent one class-session (40 minutes) engaging in their science inquiry.

Instructional design. For both classes, students were explicitly instructed to assume the role of scientists and to work together collaboratively. The immediate instructional goal was to help students learn the curriculum materials and the long-term goal was to eventually help them find and work on a science fair project. All instructional activities were designed to be similar for both the control and experimental classes (e.g., both classes were taught by the same science teacher and used the same learning materials), except that the students in the experimental condition were engaged in knowledge building. One thing to note is that a conventional routine practiced by the participating teacher in his science class is to divide students into groups, and to implement all instructional and learning activities based on these fixed groups. The classroom was consisted of six big rectangle desk, around which four to five students of the same group sit. In the present study, both the control and experimental classes also employed this grouping convention in the beginning of the study. But it was expected that students in the experimental condition who were engaged in knowledge building would be able to go beyond group collaboration and demonstrate more idea-centered characteristics of collaboration towards the end of this study.

As for the learning environment, the control class represented a conventional one with focus on structured group-based collaborative learning. Specifically, it was implemented by

means of selecting a learning task (i.e., studying sounds), defining the whole content of the task to be learned (e.g., a chapter in the textbook), dividing the whole task into sub-topical components, then having each of the six groups adopt and master one sub-topic (e.g., how sounds travel), and finally teaching other groups by making a presentation in class. Namely, they shared their piece of knowledge with the other five groups like working on a puzzle.
In contrast, while the experimental class also starts with six pre-determined groups, they were guided to work in Knowledge Forum (KF). In brief, KF is an online platform that runs on a multimedia database. It allows users to simultaneously create and post their ideas in the form of note into the database, read postings, reply to other users' notes, search and retrieve records, and organize notes into more complex conceptual representations.

There were in total twelve laptops available for use at all time in the science classroom. The experimental class mainly used computers for work in Knowledge Forum, whereas students in the control group mainly used them for group project work, for example, online search, word processing, and preparing presentation slides. It is important to note that that although the participating teacher was an experienced science and computer teacher for ten years, he had no prior knowledge about knowledge building pedagogy or experience of using Knowledge Forum. So, regular professional development sessions were provided on a weekly basis, with around 30 minutes each time, to help the teacher be familiar with knowledge building pedagogy and technology.

Data source and analysis. The main data sources included (1) students' knowledge building activities recorded in a Knowledge Forum database, and (2) group interview. First, as knowledge building is ideas-driven, with ideas recorded in the form of a note in a database, we looked into online knowledge building activity [18]. In addition, we performed social network analysis [19] to explore the online social dynamic in the experimental class.

Second, to explore students' view on collaboration, we conducted group interview [20]. There were a few reasons for using groups, rather than individuals, for interview. First, as mentioned above, it is because there is a convention in the present class to divide students into fixed groups for science instruction; as such, all class learning and instructional activities were also based on groups. We therefore decided to capitalize on this convention while conducting our interview so that students could feel more comfortable being interviewed as it resembles their routine group discussion in class. Also, the data collected will be based on their authentic group experiences. Second, it is because the main interest of this interview was to explore students' views on collaboration, using group as unit would help us elicit students' view that comes directly from their immediately belonged group interaction. The interviews were administered twice, one in the beginning and a second time at the end of the study. As each class has six pre-defined groups, the total number of groups is twelve, with each group constituted by four or five students. For this particular study, we assigned each group a group ID (i.e., G1-G12). The interview was semi-structured, focusing on the following two main dimensions: whether and how scientists collaborate. An interview protocol is shown Table 1. To conduct interview, the researcher asked questions to the group first and then facilitated each student to express his or her view by taking turns. All interview processes were video-taped. The time for each group interview was about 20 minutes. All videotapes were transcribed verbatim, and then content-analyzed using students' utterances as unit of analysis [21]. Inter-rater reliability (=.91) was calculated by determining the extent to which both raters assigned the same utterances to the same theme, with differences resolved by discussion. Table 2 shows the coding scheme developed from an open-coding process. To analyze, total number of utterances in accordance with a main theme were calculated. As our total group samples (n=12) is few, nonparametric tests (Mann-Whitney U test and Wilcoxon signed ranks test) were employed to measure pre-post change in students' views of collaboration and to test if there were any differences between the control and experimental classes.

Table 1: Interview protocol

Dimension	Sample questions (Translated from Chinese)
Whether scientists collaborate	How do scientists usually work? Do they work alone in the science lab, or do they work with others? How does scientific knowledge in textbook come from (e.g. from individual genius or group work)?
How scientists collaborate	Do scientists interact with other scientists? Why and how? Do scientists need to learn about what other scientists are doing? Why? How do scientists usually collaborate (if they collaborate)?

Table 2: Coding scheme

Category	Theme
Whether scientists collaborate	Yes
	Not necessary/no need
How scientists collaborate Group-based	1. Division of labor 2. Content of task 3. Personality
Idea-centered	4. Idea generation 5. Idea diversification 6. Idea improvement

3. Results and discussion

To answer the two main research questions, we report our findings based on the following two subheadings: (1) online activity in Knowledge Forum; and (2) change in students' views of collaboration. We elaborate each below.

3.1 Online activities in Knowledge Forum

Overall performance. To understand the general online activities and performance in Knowledge Forum, we first analyzed students' online behaviors in terms of the following three aspects: (1) individual contributions to the community; (2) community awareness of contributions made by other peers; and (3) complementary contributions as indicated by the effort to build on and connect to others' work and ideas. In terms of individual contribution, each student contributed a mean number of 21.9 notes (SD=6.79). In terms of community awareness, each student on average read a mean number of 52.4 notes (SD=39.7) in the database. In terms of complementary contribution, each student on average had 5.7 notes that were built on others' notes (i.e., 26% of the total notes contributed), and 8 notes that were collectively created with at least one co-author (i.e., 37% of the total notes contributed). Overall, the frequency of online activities was substantive as compared with previous studies also using Knowledge Forum and ten-to-eleven-years-old participants [22][18]. Nevertheless, while these behavioral measures gave a general picture of how participants worked online in this database, they tell little about how participants actually interacted with one another. To better understand the social dynamics in the community, a social network analysis (SNA) was conducted.

Interaction patterns. To further understand interaction patterns in the class, SNA was conducted using the automatic assessment tools available within the Knowledge Forum platform. Table 3 shows the interactive patterns in the experimental class over 18 weeks, using two indicators: "note-reading" and "note-linking". In this particular analysis, one connection is defined as a link between two students (i.e., reading or building-on a note), and density is defined as the proportion of connections in a network relative to the total number possible. For example, in a network of three persons, the total possible connections will be three. If the actual connections are two, the network density will be 66.6% (i.e., two connections divided by three connections). The higher the number of the density is, the stronger the social dynamics of a community is implied. An intention of adopting a knowledge-building environment in this class was to help students move beyond fixed group collaboration and be able to engage in more emergent, idea-centered collaborative learning. As Table 3 further shows about detailed results of students' interactions in phases 1 and 2, the high density of note reading and linking suggests that students' collaboration was no longer limited to small groups. They were able to exchange ideas by extensively reading a great deal of peers' notes and working to improve ideas by building on each other's notes within, not group, but the whole class community. All these quantitative online behavioral and interactive measures indicate that students were able to start to work beyond group limitations. Next we further look into whether qualitatively students also changed their views on collaboration.

Table 3. Social network analysis (SNA) in this community (N=27)

Interactivity	Phase 1 (inquiry of light)	Phase 2 (inquiry of sounds)
Note reading		
Network connections	220	248
Network density	62.67%	70.65%
Note linking		
Network connections	114	121
Network density	32.47%	34.47%

3.2 Students' views on collaboration: Whether and how scientists collaborate

Table 4 shows pre-post changes in students' view on whether scientists collaborate. First, as baseline comparison, a statistics test using only pre-assessment data was conducted and it showed there was no significant difference (Mann-Whitney U=17, p>.05) between the control group and the experimental group. Second, Wilcoxon signed rank tests were conducted to measure changes from pre-assessment to post-assessment within the control and experimental classes, respectively; significant increases were found for both the control group (p<.05) and the experimental group (p<.05). Finally, an additional comparison between the control and the experimental classes in terms of the extent of their pre-post change was conducted and it was found there was no significant different between the two classes (Mann-Whitney U=10.5, p>.05). This suggests that conventional group-based instruction and knowledge building instruction were both effective in helping students see the importance of collaboration in scientists' knowledge work. Arguably, this may be because both groups (1) were practicing collaboration in class (although different kinds); and (2) students were explicitly instructed to play the role of scientists and work collaboratively.

Table 4. Pre-post changes in students' view about collaboration (N=12)

	Control group		Experimental group	
	pre-assessment	post-assessment	pre-assessment	post-assessment
Whether scientists collaborate	1.00	5.17	0.67	6.17
Types of collaboration				
1. Group-based collaboration	6.83	6.50	7.83	7.50
2. Idea-centered collaboration	4.17	4.33	2.67	9.83

In terms of how scientists collaborate, two major views (themes) developed from the coding process were: group-based and idea-centered collaboration.

Group-based collaboration. To understand whether the two types of instruction (conventional vs. knowledge building) influenced students' view on group-based collaboration, nonparametric tests were conducted. Table 5 also shows pre-post changes in students' view on group-based collaboration. First, as baseline comparison (only pre-assessment data was used), it showed there was no significant difference between the control group and the experimental group (Mann-Whitney U=17.5, p>.05). Further comparison between the control and the experimental classes in terms of the extent of their pre-post change was conducted and it was found there was also no significant difference between the two classes (Mann-Whitney U=15, p>.05). The findings suggests that neither conventional nor knowledge building instruction had impacts on students' prior view on group-based collaboration. In other words, engaging students in knowledge building had no effect on their prior view of group-based collaboration.

A more in-depth analysis further suggests that the reasons why scientists perform group-based collaboration may include: division of labor, nature of task, and personality issue. First, there is a great emphasis on division of labor (i.e., who does what). For instance, when asked to give an example of collaboration, a student said, "…in digging up dinosaur fossil, scientists may do some division of labor, they may make someone dig dinosaur fossils, someone paint plaster, someone call the helicopter, and someone moves it up to the helicopter" (G3) Second, it is highly task-driven, with the content or the difficulty level of a task well-specified. For example, when discussing how to divide labor, one student said, "they can do it alone if it's a simple project. But once the project is complex, team work will be needed." (G1). Third, personality plays an important role in division of labor. For example, a student said, "Some scientists prefer to do research alone because they are shy or afraid to interrupt others" (G5).

Idea-centered collaboration. To understand whether the two types of instruction (conventional vs. knowledge building instruction) also have impacts on students' view of idea-centered collaboration, additional analysis was conducted. Table 5 also shows pre-post changes in students' view on idea-based collaboration. As baseline comparison, a nonparametric test using only pre-assessment data showed there was no significant difference between the control group and the experimental group (Mann-Whitney U=8.5, p>.05). Further comparison between the control and the experimental classes, in terms of the extent of their pre-post change, however, showed a significant difference between the two conditions (Mann-Whitney U=2, p<.01), with the experimental class showing a significant pre-post change in students' view on collaboration. The findings suggest that knowledge building pedagogy, as compared with conventional instruction, is more likely to help students develop a more idea-centered view of collaboration.

To elaborate further, a more in-depth examination suggests that students mentioned three main reasons in support of scientists performing idea-centered collaboration: idea generation, idea-diversification and idea-improvement [11]. In terms of idea generation, for example, one student said, "[scientists] discuss together for brainstorming ideas and then research together" (G10). In terms of ways for idea exchange and diversification, a student proposed, "Scientists may put their ideas on Internet to get more ideas from other scientists and they use these ideas to make further inference" (G10). Finally, in terms of idea improvement, when discussing how knowledge is advanced, a student said, "They [scientists] may start to work on previous scientists' idea and then continue working on that idea" (G4). Overall, it is posited that providing students with Knowledge Forum in which students are able to work with ideas as basic knowledge unit may be a key to broaden students' view on collaboration, thus helping them see that group-based teamwork is only one way to collaborate and it may be complimented by collaboration around ideas.

4. Conclusion

Arguably, depending on one's instructional goal, both types of collaborative learning discussed above can be useful, and with careful design, they can be used to complement individual learning. Unfortunately, to a large degree, most science learning in schools still highly focuses on individual learning, rather than collaborative learning. Specifically in the Taiwan context, as noted by [23], most students believe that science learning is all about memorizing textbook knowledge, preparing for tests, practicing tutorial problems in order to get good grades. Namely, science learning is still more concerned about individual knowledge growth, rather than collaborative knowledge work. And if there is any collaborative learning in science classes, the kind of collaborative activities are also quite inclined to the kind of group-based collaboration, highlighting division of labor and mastery of certain content knowledge, thus, neglecting the kind of more creative and idea-centered collaboration. As a result of such learning tradition, students' view on collaboration also appears to be quite limited.

Our study provided an initial look at the impact of engaging students in knowledge building on their practice and views of collaboration. We suggest the following areas for future research: First, we conjecture that there may be a relationship between types of collaboration and students' view on nature of science. Working collaboratively with knowledge around ideas, by brainstorming ideas and collectively improving ideas, in order to solve real-life knowledge problems, implies not only facilitating among students an idea-centered view of collaboration, but also engaging them in an idea-centered education [14]. As such, it may be possible to help students develop a more constructivist-oriented epistemological perspective that sees knowledge as tentative and subject to changes (i.e., understanding that ideas are improvable) [24]. Moreover, we also speculate that long-term exposure to idea-centered collaboration may also have a positive influence on the development of students' problem-solving capacity. It would be interesting to further investigate how students would solve real-life science problems after engaging students in knowledge building for a longer period of time.

Acknowledgements

The preparation of this paper was supported in part by a grant from the National Science Council, Taiwan, NSC 97-2511-S-004-001-MY2.

References

[1] Slavin, R.E. (1983). When does cooperative learning increase student achievement? *Psychological Bulletin, 94*, 429-445.
[2] Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: LEA.
[3] Evans, P., & Wolf, B. (2005). Collaboration rules. *Harvard Business Review, 83*(7), 96-104.
[4] Gloor, P. A. (2006). *Swarm creativity*. New York: Oxford University Press.
[5] Latour, B., & Woolgar, S. (1986). *Laboratory Life*. Princeton, NJ: Princeton University Press.
[6] Merton, R. K. (1973). *The sociology of science*. Chicago: Univ. of Chicago Press.
[7] Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.
[8] Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company*. New York: Oxford University Press.
[9] Rycroft, R. (2003). *Self-organizing innovation networks: Implications for globalization*. Washington, DC: George Washington Center for the Study of Globalization.
[10] Hong, H.-Y., & Sullivan, F. R. (2009). Towards an idea-centered, principle-based design approach to support learning as knowledge creation. *Educational Technology Research & Development, 57*(5), 613-627.
[11] Hong, H.-Y., Scardamalia, M., & Zhang, J. (in press). Knowledge Society Network: Toward a dynamic, sustained network for building knowledge. *Canadian Journal of Learning and Technology.*
[12] Zhang, J. (2009). Towards a creative social Web for learners and teachers. *Educational Researcher*, 38, 274-279.
[13] Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In *Encyclopedia of Education* (pp. 1370-1373). New York: Macmillan Reference, USA.
[14] Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago: Open Court.
[15] Scardamalia, M., Bereiter, C., & Lamon, M. (1994). The CSILE project: Trying to bring the classroom into World 3. In K. McGilley (Eds.), *Classroom lessons* (pp. 201-228). Cambridge, MA: MIT Press.
[16] Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (2007). Socio-cognitive dynamics of knowledge building in the work of 9- and 10-year-olds. *ETR&D, 55*(2), 117-145.
[17] Zhang, J., Hong, H.-Y., Scardamalia, M., Teo, C. L. & Morley, E. A. (accepted). Sustaining knowledge building as a principle-based innovation at an elementary school. *Journal of the Learning Sciences*.
[18] Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge building communities. *Journal of the Learning Sciences, 18*(1), 7-44.
[19] Wasserman, S., & Faust, K. (1994). *Social network analysis*. Cambridge, UK: Cambridge Univ. Press.
[20] Frey, J. H., & Fontana, A. (1991). The group interview in social research. *Social Science Journal, 28*(2), 175-187.
[21] Strauss, A. L., & Corbin, J. (1990). *Basics of qualitative research*. Newbury Park, CA: Sage.
[22] Hong, H.-Y. & Scardamalia, M. (March, 2008). *Using key terms to assess community knowledge.* Paper presented at the annual conference of American Educational Research Association (AERA), New York.
[23] Tsai, C.-C. (1998). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education, 82*(4), 473-789.
[24] Hong, H.-Y. & Lin, S. P. (2010). Teacher-education students' epistemological belief change through collaborative knowledge building. *Asia-Pacific Education Researcher (19)*1, 99-110.