Promoting 5th Graders' Views of Science and Scientific Inquiry in an Epistemic-Enriched Knowledge-Building Environment

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Abstract: This paper reports on an ongoing study that examined the design of a knowledge-building environment that integrates knowledge building and epistemic change theories in fostering conceptual and epistemic growth. The study uses a quasi-experimental design in which four classes of 5th graders in Hong Kong participated in a unit focusing on electricity. The intervention involved students' collective inquiry and, epistemic reflection on what science is about; students used Knowledge Forum® to collaboratively work on pursuing ideas; and students reflected on scientific progress with their own knowledge building inquiry. A scheme was developed in assessing students' views of science; and results showed significantly stronger effects for the knowledge-building group compared with the regular inquiry group on epistemic and conceptual learning. Regression analysis showed that students' forum engagement and epistemic views contributed to their posttest conceptual understanding over and above prior science knowledge. Qualitative analysis suggested how students' experience in knowledge building might shape students' understanding about the nature of science and improve their conceptual understanding.

Epistemic cognition, or thinking about the nature of knowledge and knowing, has received much research attention in recent decades. Substantial evidence has shown that sophisticated personal epistemologies are important predictors of learning, including learning strategies and processes and conceptual change (Hofer & Pintrinch, 2002). Of particular interest about students' views of knowledge and knowing relates to what they think about the nature of science and how scientific knowledge is created. Although there is widespread recognition of the importance of scientific inquiry, often students do not think of science as an epistemic idea-driven and theory-building process. Rather children tend to think of science as concrete activities, and scientific inquiry as acquiring sets of skills such as the methodical collection of data and testing of variables (Chinn & Malhotra, 2002). The purpose of this study is to investigate students' epistemic understanding of science as a theory-building process in the context of their working on knowledge building inquiry supported by Knowledge Forum®, a computer-supported collaborative learning environment. Specifically, the goal is to design and examine a learning environment to foster students' epistemic and conceptual growth via linking views of science with knowledge building inquiry, and also to investigate the intertwined relationship between the designed environment, epistemic cognitions and conceptual understanding.

Theoretical Perspectives

Epistemic Cognition and Views of Science

There are different research traditions that examine what people think about the nature of knowledge and nature of science. Some extended the psychometric tradition initiated by Schommer (1990) and Hofer & Pintrich (1997) and took a multidimensional approach to examine epistemic beliefs; examples of the examined dimensions included certainty of knowledge, source of knowledge, justification for knowing, and development of knowledge (Conley et al., 2004). Another major approach developed from research in science education. For example, Lederman and colleagues (2002) examined several aspects of the nature of science (NOS), such as the empirical nature of science, tentative nature of science, creative and imaginative nature of science, and inferential nature of science, and so on. A third tradition examines students' epistemology of science from the "role of idea" perspective. Herein, science is perceived as a theory building process and the construction of ever-deeper explanations of the natural world (Carey et al., 1989; Chuy, et al., 2010). Carey et al. (1989) developed a clinical interview protocol and identified three general levels of understanding about science among middle school students, ranging from seeing science as discovering facts and making inventions, to seeing it as constructing explanations for phenomena. Later Smith et al. (2000) extended this line of research and elaborated science as theory building, and Chuy et al. (2010) further developed the interview protocol to examine children's understanding of science in relation to knowledge building. This study follows this tradition (Bereiter et al., 1996) and examines students' understanding of science as an idea-driven and theory-building process. We choose to build on this line of research mainly for two reasons: (1) science as a theory-building process (Kuhn, 1970) is important but often overlooked and portrayed merely a process of observation and experimentation in school science (Carey & Smith, 1993); (2) how students understand the theoretical progress of science may be facilitated as they build knowledge together; and such research direction may help develop new instruments and extend our understanding of epistemology in relation to community process. We use the term epistemic cognition to refer to a broad notion that encompasses both cognitions of the nature of knowledge (Hofer & Pintrich, 2002) and nature of science (Lederman et al., 2002).

Research has shown that epistemic cognition influences students' conceptual change (Mason, 2000; Qian & Alvermann, 1995), for example, epistemic cognition may affect learners' intention to restructure knowledge (Vosniadou & Brewer, 1987). However, many previous studies conceptualize the relationship between epistemic cognitions, thinking and learning within theories of knowledge construction within individual learners. As learning theories have shifted from individual to collective, knowledge construction is no longer perceived as an individual but a social process (Brown et al., 1989). There is a need to extend investigation of epistemic cognition of scientific process to socio-cognitive processes and to examine how it may influence cognition in social context. As well, scientific progress and theory building evolves in scientific communities via collective advances, not only individual endeavors. Thus far, there are few investigations looking into the social and collaborative aspects of epistemic cognition. This study will examine students' views of science as a social-cognitive and community process, and investigate how these views relate to students' knowledge building and conceptual understanding.

Computer Supported Knowledge Building, Reflection, and Epistemic Change

Knowledge building is an educational model that has attracted much research attention in learning sciences and CSCL (Scardamalia & Bereiter, 2006). Its role in student learning and cognition has been discussed in a growing number of studies (e.g., Lee et al., 2006; Zhang et al., 2007; van Aalst & Chan, 2007). Knowledge building emphasizes on students, similar to scientists, working as a community and taking collective cognitive responsibility for idea improvement (Scardamalia, 2002). In knowledge building, students' collaborative discourse is supported by a computer supported collaborative learning platform, Knowledge Forum®(KF), in which students pose questions, make conjectures, co-construct explanations, reorganize ideas, and revise and integrate ideas. To make knowledge building more explicit, knowledge building principles (Scardamalia, 2002) have been proposed to guide students and teachers' knowledge building practice. These principles provide epistemological scaffolds for students' knowledge work in their community (usually their class), as students work with the principles, that might help them move from naive epistemology to more sophisticated one. Primarily, "Knowledge building is not just a pedagogical approach but a theory of epistemology" (Bereiter, 2002). The knowledge building principles, e.g., improvable ideas; rise above; constructive use of authoritative sources, and their technological function on Knowledge Forum, that is, making ideas explicit and as subject for building on and revision, have important epistemic indications for students.

The influence of knowledge building and metacognitive reflection on students' conceptual understanding has been examined (van Aalst & Chan, 2007), and the important relations have been identified among epistemic cognition, knowledge building, and conceptual understanding (Chan & Lam, 2010). Research on science and epistemic inquiry has examined the roles of scaffolding epistemic standards and scientific practice (Sandoval et al., 2005), however, fewer studies have attempted to design epistemic-enriched knowledge-building environments helping students to reflect on their knowledge building practice that mirrors the theory-building nature of science. Research has indicated (Carey et al., 1989) that if students are to understand the role of theory in science, they need to be engaged actively in the explanation-based theory-building process and make metacognitive reflections about the process. As knowledge-building model emphasizes idea improvement and collective advances, it provides a rich environment to understand and to foster students' understanding of the nature of science from the perspective of theory building. Accordingly, we aimed to design a knowledge building environment, emphasizing the theme of students working as communities and focusing on epistemic standards and the practice of scientists. A key idea is that when students working on ideas in knowledge building, they are better able to experience the role of idea and theory building in science, which would in turn foster their epistemic views and conceptual understanding.

To iterate, this study aimed to design an epistemic-enriched knowledge-building environment to foster more sophisticated epistemic cognitions and conceptual understanding among students. Three research questions were addressed: (1) Do students engaging in epistemic enriched knowledge building achieve more epistemic and conceptual growth than students in a regular inquiry-based learning environment? (2) What are the relationships among knowledge building, reflection, epistemic cognition, and conceptual understanding? (3) How do the designed environment help students improve their epistemic cognition and conceptual understanding? This paper reports preliminary findings for these questions.

Methods

Participants and Procedure

102 5th graders (age ranging 10-11) in four science classes in Hong Kong participated in this study. The experimental group included two classes, Class 1 (*n*=33) and Class 2 (*n*=19), engaging in computer-supported

knowledge-building inquiry with epistemic reflection. The comparison group also included two classes, Class 3 (*n*=26) and Class 4 (*n*=24), taught with regular inquiry-based approach with metacognitive reflection. The experimental classes were selected according to teachers' knowledge building experience, as two teachers (Class 1 & Class 2) have used knowledge building pedagogy for 4 years, and the other two (Class 3 & Class 4) are familiar with general inquiry-based approach. The study was conducted in six sessions lasting for about three weeks. All four classes worked on an extended topic from their textbook study of electricity. These four classes have similar access to learning resources (video, experiment equipment, reading material) except that the experimental classes used knowledge-building design that involved Knowledge Forum and epistemic reflection.

Designing a Knowledge Building Environment for Epistemic and Conceptual Change

The experimental environment was designed based on an integration of knowledge building pedagogy (Chan, 2011) and epistemic change theory (Bendixen, 2002). Primarily we engage students in a knowledge-building environment to pose problems, questions and explanations, and to make their ideas improvable, and to advance community knowledge as in scientific communities. We also adapted epistemic change model that emphasizes epistemic doubt and resolution of doubts, enriched in a community of knowledge builders. Students work on collective inquiry as communities of little scientists. The specific design principles are described below:

(1) *Articulate and activate prior understanding*. Before engaging in inquiry, students were asked to write down what science is about as well as their understanding about electricity, so that their ideas can be made visible in the class and open for revision. This was designed not only for creating a knowledge building culture where ideas can be examined, but also for promoting students' epistemic awareness and triggering their epistemic doubt by learning about their peer's different epistemic theories.

(2) *Start inquiry with authentic problems*. We first provided students with everyday situation (video on lemon juice and salt water conducting electricity), to stimulate their wonderment about conductors. Then they wrote out their questions and ideas on Knowledge Forum based on this material. Students also worked together in groups to test out the conductivity of different materials. Inquiry-based activity and Knowledge Forum were intertwined: students continually worked on Knowledge Forum after the experiment. Scaffolds were provided on Knowledge Forum to help them build and revise theories and explanations: "I need to understand", "my theory (explanation)", "new information", "a better theory (explanation)", "your theory cannot explain".

(3) *Deepen inquiry through knowledge building talk and experiment.* In order to facilitate good knowledge building discourse and engage them in deep construction of knowledge, knowledge-building principles (e.g., improvable ideas, epistemic agency) were explicitly discussed in the class, and linked to scientific process and scientific community. To test the ideas discussed on Knowledge Forum, students worked in groups to design experiments and make posters. Scaffolds were provided to facilitate this collective inquiry process: "our question", "our theory", "our hypothesis", and "our experiment design". After testing their ideas, students continued to write on Knowledge Forum to revise their theories. Meta-views were also created to encourage students to rise-above their existing theories.

(4) *Trigger and resolve epistemic doubt through collective epistemic talk.* Classroom discourse was conducted to scaffold students toward viewing scientific inquiry as a theory-building and theory-revision process. The teachers triggered conceptual and epistemic doubts and engaged students to reflect on the experiments and evidence; students were encouraged to think like scientists as they pursued inquiry and considered the need for revising their hypotheses and theory. Online and offline discourse was linked: Students discussed 'electricity' in one view alongside another 'view' that asked them to reflect on how scientists construct knowledge, and how their work might be similar to scientists.

(5) *Understanding science as theory-building through collective epistemic reflection.* Knowledge building emphasizes collective inquiry and aims to help students to understand the social and collective nature of science. Students therefore were asked to reflect on their own scientific and knowledge building inquiry process as "little scientists." Experts' inquiry process and epistemic theories were illustrated on a worksheet pertaining to four different models of scientists, and students were asked to reflect and identify the part that they think they have experienced. This was a scaffold designed to help students connect what they do and what scientists do. Teachers then promoted a discussion among students to investigate the similarities between their own collective inquiry process and the social construction process in scientific community.

The comparison classes went through similar processes as the experimental classes. They first wrote their prior conceptions about electricity and nature of science, and watched the same video to start inquiry. They did the same experiments on conductors, and worked in groups to design experiments to test their own ideas. The scaffolds provided in the group inquiry were same as the experimental group. The only major difference is that the experimental group used Knowledge Forum for inquiry, and had epistemic talk and reflection. To make the comparison more equivalent, the comparison group students were asked to write reflection journals on papers after class, and were provided with metacognitive scaffold, such as "my new learning".

Measures

Written Questions on Epistemic Views of Science

All children were administered the written questionnaires at the beginning and end of the unit. Children's epistemic views of science were measured with 8 written questions developed in this study based on Carey et al. (1989), Smith et al. (2000), Chuy et al. (2010), and Lederman & Ko's (2004) items. Premised on the framework of science as theory building, four components were identified: (1) Role of idea (2) Theory building and theory revision (3) Theory-fact understanding; and (4) Social process of scientific progress. Examples of the questions included: "What is science"; "What do scientists do"; "Why do scientists do experiments"; "Scientists may have different even contradictory ideas, do you think it is good for science, and why".

Interviews on Epistemic Views of Science

8 students from each class (i.e., n = 32) were interviewed before and after the intervention with the epistemic cognitions interview protocol to examine their epistemic and conceptual change process. The first part of the interview questions were similar to the questionnaire items but allowed students to elaborate on their thinking about science; the second part had questions that mapped with the first parts but probed students' understanding of their own inquiry process. The third part of the interview asked students to reflect how they had changed their views of science and conceptual understanding about electricity. These data are currently being analyzed.

Conceptual Understanding

Students' conceptual understanding was measured with a knowledge test containing different parts: The first tested students' understanding about the conductivity of different materials (e.g., metal, distilled water, juice, graphite); the second asked them to give explanation on why some materials conduct electricity, the third part asked what they knew about electricity and what questions they had. Students' responses to the first part of the test were scored according to the scientific correctness of answers, and their responses to the second and third parts were coded on a 4-point scale based on depth of explanation.

Knowledge Building Engagement on Forum

Students' knowledge building engagement was assessed with a software Analytic Toolkit (ATK) developed by the Knowledge Building Research Team at the University of Toronto (Burtis, 1998). We selected two indices to illustrate students' collaboration on Knowledge Forum: percentage of notes *linked* and percentage of notes *read*.

Epistemic Reflection on Science (Students as Little Scientists Worksheet)

As discussed earlier, the worksheet described the models and practice of four different scientists involving concrete day-to-day work as well as theory-building process of scientists. Students were asked to identify aspects that were similar to what they did in knowledge building inquiry. This worksheet provides a scaffold for students to engage in classroom discourse; and at the same time, it provided data on students' reflection of their inquiry and epistemic process. A 5-point scale was developed to code the worksheet ranging from naïve, concrete, elaborated, theory-change and social-community processes of scientific progress.

Analysis and Results

Characterization and Change of Epistemic Views of Science

Students' responses to the epistemic questionnaire were coded to identify students' epistemic cognition ranging from viewing science as making concrete materials to an idea-driven and theory-building process. There are many systems and this coding scheme is based on the theoretical framework, and in line with cognitive studies, different levels are included. Based on top-down and bottom-up analysis, a 4-point coding scheme was developed, for example, for one of the items on role of idea (what is science?), at level 1, students responses showed a rudimentary understanding focusing on concrete activities (e.g., "*Science is about inventing new things, for the convenience of people")*; at level 2, students showed some awareness of the existence of abstract unseen entity in science (e.g., "*Science is about investigating some questions");* at level 3, responses reflect some understanding about the relationship between theory and experiment, and the explanatory nature of science (e.g., "*Science is an investigation, it involves experiments; to explain all kinds of phenomenon"*); at level 4, responses indicate a deeper understanding of theory building (e.g., "*Science is about making theories through experiment, then they do different experiment to revise the theory"*). For the item on scientific progress as a social process, responses at level 1 do not appreciate the role of different ideas for scientific progress (e.g., "*it is not good to have different ideas. When you have too many ideas, it is hard to find answer.*"); responses at level 2 show some superficial understanding (e.g., *"it is a good thing, you can compare and see which one is right*); responses at level 3 appreciate of the role of idea interaction in science (e.g., "*it is a good thing, different ideas can inspire scientists*"); responses at level 4 indicated better understanding about the role of different ideas for theory improvement/knowledge creation (e.g., "*scientists have different ideas, they test them with experiments; they may understand some new ideas...organize them.. and make a new theory"*).

To examine the intervention effects on the change of epistemic cognition over time, a 2 x 2 (group x time) repeated measures MANOVA was performed for the scores of four scales (Table 1). The participants were nested within classes and therefore the measurements were not statistically independent, which may affect Type I error rates. All alphas were therefore set at .01. Results revealed statistically significant multivariate effects; Follow up univariate ANOVAs revealed significant main effects for time for: role of idea, $F(1,100)=85.06$, $p<.001$, Partial eta^2=.46; theory building, $F(1,100)=37.07$, $p<.001$, Partial eta^2=.27; social process, $F(1,100)=8.95$, $p<.01$, Partial eta^2=.08; and theory-fact understanding, $F(1,100)=5.59$, $p<.05$. Partial eta^2=.05, suggesting both knowledge-building and inquiry groups improved over time. There was also a significant main effect for groups for role of idea, theory building, and social process. Importantly, significant time x group interaction effects were obtained on role of idea, $F(1,100)=16.89$, $p<.001$, Partial eta^2=.14, theory building, $F(1,100)=9.79$, $p<.01$, Partial eta^2=.09, and social process $F(1,100)=17.07$, $p<.001$, Partial eta^2=.15. The interaction effect was not significant for theory-fact understanding. Results indicated that knowledge-building group had more gains on epistemic views of science than did the comparison group.

Table 1: Pre and posttest epistemic cognitions mean scores (SD in parentheses) across classes

	Knowledge building group (n=52)		Comparison group (n=50)	
	Pre-test	Post-test	Pre-test	Post-test
Role of Idea	1.26(.33)	2.03(.66)	1.12(.32)	1.42(.49)
Theory-Fact	1.44 (.67)	1.79 (.94)	1.42 (.84)	1.54 (.73)
Theory Building	1.63(.51)	2.28(.70)	1.36(.56)	1.57(.46)
Social aspect	2.37(.95)	3.12(.94)	1.98(.87)	1.86(.83)
Epistemic overall	6.69 (1.43)	9.21 (2.07)	5.88 (1.63)	6.39 (1.71)

Changes in Conceptual Understanding

The mean and SD of the pre and post scores were 1.11 (.23) and 1.55 (.18) for knowledge building group (n=52), and .94 (.14) and 1.12 (.15) for comparison group (n=50) at pre and posttest respectively. Repeated measure ANOVA was conducted to test the intervention effect for conceptual understanding. The results showed a time effect, $F(1,99)=217.18$, $p<.001$, Partial eta^2=.687, and a group effect, $F(1, 99)=1.6.31$, $p<.001$, Partial eta^2=.518. There was also a significant time and group interaction effect, $F(1,99)=39.00$, $p<.001$, Partial eta^2=.283. These results indicate that both groups improved their conceptual understanding over time, but the knowledge building group had a larger gains than had the comparison group.

Relations between Knowledge Building, Epistemic Views &Conceptual Understanding

The second question investigated the relationship among knowledge building, epistemic cognition, and conceptual understanding, and examined the prediction of different variables on posttest conceptual understanding. Analyses were conducted within the knowledge building groups (n=52) as ATK indices were available only for this group. Correlations analyses indicated that students' post-test conceptual understanding was related to post-test epistemic cognition and KF-link indices. As well, students' post epistemic cognition was related to their epistemic reflection. Primarily, students' engagement in Knowledge Forum and their epistemic cognition are related to their conceptual understanding after instruction.

Table 2: Correlation among post epistemic cognition, post conceptual understanding, KF collaboration (link & read), and epistemic reflection (n=52)

	Epistemic cognition	Conceptual understanding	KF link	KF read
Conceptual understanding	.310*	1		
KF link	0.136	.304*	1	
KF read	.242	0.17	.287*	1
Epistemic reflection	.377**	0.143	.304*	0.155

Note: *p<.05; **p<.01;

Prediction of Prior Knowledge, Epistemic Cognition and Knowledge Forum Activities on Conceptual Understanding

Hierarchical regression analyses were conducted for the knowledge-building group (n=52); first entering pre-test scores, followed by Knowledge Forum activities, and then epistemic cognition. Results showed that prior conceptual understanding explains 13% of variance (R^2=.13), when Knowledge Forum note links was added, an additional 6.2% variance was explained. When post epistemic cognition was added, another further

8.3% variance was explained. These results indicated that over and above prior knowledge, students' collaboration on Knowledge Forum, epistemic cognition contributed to the post conceptual understanding.

Table 3. Hierarchical regression on post conceptual understanding with prior conceptual understanding, KF note link, and post epistemic cognition (n=52)

	R	R^2	R^2 Change	F Change	Sig.
Prior conceptual understanding	.36	.13	.132	7.59**	.008
KF link	.44	.19	.062	3.75(*)	.058
Post epistemic cognition	.526	.28	.083	5.52*	.023

Note: *p<.05; **p<.01

Prediction of Learning Context, Prior Knowledge, Epistemic Cognition on Conceptual Understanding

Hierarchical regression was also conducted to examine the contribution of posttest epistemic cognition score and learning context (group) to students' posttest conceptual understanding (*n*=101). The learning context was coded into two variables (KB group=1, None KB group=0). Results showed that prior conceptual understanding explained 26.7% of the variance (R^2=.267). When post epistemic cognition was added, additional 27.7% of the variance was explained. When learning context was added, additional 16.5 % of the variance was explained. Results indicated that over and above prior knowledge, epistemic cognition and knowledge building environment contributed to post-conceptual understanding.

Table 4. Hierarchical regression on conceptual change score with prior conceptual understanding, post epistemic cognition, and learning context (*n* = 101)

	R	R^2	R^2 Change	F Change
Prior conceptual understanding	.52	.267	.267	36.098***
Post epistemic cognition	.74	.544	.277	59.623***
Learning context	.84	.709	.165	55.122***

Note: ***p<.001

The Epistemic and Conceptual Change Process: Preliminary Observation

The third research question examined how knowledge-building environment might support the observed epistemic and conceptual change. Consistent with the quantitative findings, qualitative analysis of students' post interview data also revealed the possible positive impact of knowledge building on students' epistemic and conceptual change. Table 5 shows a comparison of two students' reflections on their own inquiry process, one from the knowledge-building group and one from the comparison group.

Table 5: An example of students' interview responses about their own inquiry process

Student A (from knowledge building group)	**Student B (from comparison group)**
I: What makes a good inquiry-based discussion? A: Classmates will bring out questions, there will be hypothesis, theories….new knowledge is produced in the theories. In [working on] new knowledge, there are things [we] don't understand, so we will keep asking questions…. Then there are more questions, hypothesis, and knowledge, etc. It keeps circulating… I: Is it good to have different ideas in your discussion? A: **It is the same like what I said about scientists**. It is good, with different theories, we can have better theory. I: how can different theories help you find better theory? A: the different ideas will help you revise your theory, which means, your theory will become better... I: How was new knowledge created in your class? A: We kept discussing, brought out questions, hypothesis, theories...there may be new knowledge there..…and as I said, it is a cyclic process	**I: What makes a good inquiry-based discussion?** B: everyone discusses with each other.. I: any others? B: no ….. I: Is it good to have different ideas in your discussion? B: If you can do it separately (experiment), it is ok to have different ideas….but we were working as a group, therefore it is not good to have different ideas. I: How was new knowledge created in your class? B: We need to try another activity and find a correct answer, then we get new knowledge.

As suggested in these excerpts, student A (knowledge building group) seemed to have a better sense that scientific knowledge is socially constructed, and that it improves in a cyclic manner through constantly questioning and theorizing. He also appreciated the role of different ideas in improving knowledge. However, student B thought of science as activities and getting something right for new knowledge. Student A was alluding to his experience as they worked on scientific inquiry and discussion. These excerpts provided some glimpses into how the knowledge-building environment enriched with epistemic reflection might have influenced students' views of science. Other examples are also included to show correspondence between students' epistemic understanding of science and their experience with Knowledge Forum. When asked "*how do you think scientists create new knowledge",* one knowledge building student said, *"scientists will construct a new theory based on previous theories. Just like the working on Knowledge Forum, you will write and type something under a question, and it will be revised gradually, or a new theory will be proposed.*" From this excerpt, we can see how students' knowledge building engagement and the visualization of ideas on Knowledge Forum may have helped them understand the theory construction process of scientists.

To further understand how knowledge building may have possibly provided students with an epistemic environment, we examined student's understanding of scientists' inquiry and also reflection of their own inquiry process. For example, a knowledge-building student LHT reflected: "*When working on Knowledge Forum, underneath different themes people posted questions…it was all about electricity, but we talked about different aspects of it, e.g., some were wondering why salt water can conduct electricity, some others were wondering why fruit can conduct electricity…. Underneath all these questions, there were different [ideas], some of which were theories. You might question these theories, so you asked follow-up questions. However, people might even question your follow-up questions, so you had to revise it…. Some used the scaffold "your theory cannot explain" in their responses, which means your theory might have problems. It keeps going on like this, and it becomes a big cluster of notes full of questions, theories, and questioning etc……*". While talking about her view of scientists' inquiry, this student mentioned a similar progressive process: "*….after scientists make a theory, there may be follow-up questions…." "…Theory will change with time, when other scientists make another investigation of the theory, they may find some problems in it. Then they will do experiment to test…. and it will be changed*". These excerpts provided glimpses into how knowledge-building inquiry, supported by Knowledge Forum, may have shaped students' understanding about the progressive and collective nature of science, and helped them revise their theories and explanations through its social mechanism.

Conclusion, Implications and Significance

This study designed a knowledge-building environment that attempts to integrate knowledge building and epistemic change theories, and examined the role of such design in facilitating epistemic and conceptual change in fifth graders. In the process, we developed a coding scheme to examine children's epistemic understanding of science focusing on role of idea, theory-fact understanding, theory building and social process of scientific progress. Consistent with the research of Carey et al. (1989) and Smith et al. (2000), results showed variation among these participants ranging from seeing scientific inquiry as concrete activity to viewing it as an idea-driven theory-building process. As well, these children demonstrated understanding of scientific progress as propelled by inquiry and social processes in a community. Our findings showed that grade 5 students working in the knowledge-building environment obtained significantly more changes towards more sophisticated views of scientific inquiry, compared to students in the regular inquiry-based classes; and they also obtained higher scores on conceptual understanding of electricity. To understand the relationships among knowledge building, epistemic understanding, and conceptual understanding, correlation and hierarchical regression analysis were conducted. It was found that knowledge building environment and post epistemic understanding significantly contributed to students' post conceptual understanding. Chan and Lam (2010) examined role of knowledge-building in facilitating epistemic and conceptual growth, the current study extended it to integrate epistemic dimensions in the knowledge-building design and suggested the importance of helping students to become aware of and resolve their epistemic doubt by scaffolding their collective epistemic inquiry and reflection for epistemic change.

In this study, the key design involved scaffolding children's work as "communities of scientists" and knowledge builders pursuing inquiry into problems, constructing explanations, using authoritative sources of information, improving their ideas and pursing for collective inquiry and new knowledge. While most studies on knowledge building have examined elementary children's scientific understanding, we explicitly focused on helping students to have epistemic reflection. We attempted to help students to reflect on the nature and process of science focusing on theory building as they experienced their own knowledge building processes when they studied electricity. Qualitative analysis of students' interview reflection suggested how the designed environment may have helped students understand science as a collective theory building process, and subsequently helped them revise and improve their theories and explanation.

Although scientific inquiry is much emphasized, students often think of science as lists of activities and skills rather than an idea-driven and theory-building process for creation of new knowledge. This study explored a design that helped students to *mirror* their understanding of science with their engagement in knowledge building inquiry, that merits further investigation. As well, the study extended the line of inquiry on epistemic understanding of science that focused on the role of idea in science, and expanded on social and community processes of scientific progress; these findings suggest possible research direction on examining social aspects of epistemic cognition. This study is an ongoing study and further analyses of process dynamics would be undertaken to examine the nature of collaborative discourse on Knowledge Forum, and to understand the epistemic and conceptual change mechanism (e.g., the role of epistemic doubt) so as to provide a more coherent picture about the relationship among knowledge building, epistemic cognition, and conceptual understanding.

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