Fostering Epistemological Beliefs and Conceptual Change In Chemistry Using Knowledge Building

Abstract: This study investigated the role of knowledge building in fostering conceptual and epistemological changes in the context of Grade 10 chemistry students collaborating on Knowledge Forum in a Hong Kong classroom. Participants were 40 experimental and 39 comparison students experiencing knowledge building and traditional instruction respectively. Students engaging in knowledge building posed questions, generated theories and hypothesis, constructed explanations, and revised their theories mediated by Knowledge Forum. Various measures were collected at pre and posttests including epistemological beliefs, conceptual-change questions and online discourse and reflection. Results indicated that experimental students made more gains than comparison students on both conceptual and epistemological measures. Epistemological beliefs and knowledge-building reflection were correlated with science learning; regression analyses indicated that knowledge-building reflection and inquiry contributed to conceptual change over and above prior knowledge and epistemological beliefs. Implications of knowledge building for developing epistemological beliefs and meta-conceptual awareness for conceptual change are discussed.

Introduction

Considerable debates and interests have now been given to examining cognitive and socio-cultural perspectives of learning (Anderson, Reder & Simon, 1997) and conceptual change (Mason, 2007). Traditionally, conceptual change has been viewed from the cognitive perspective emphasizing cognitive conflict (Posner, Strike, Hewson & Gertzog, 1982), ontological shifts (Chi, Slotta & de Leeuw, 1994) and epistemological commitment in knowledge restructuring (Vosniadou & Brewer, 1987). Currently, conceptual change has been examined from the socio-cultural perspective emphasizing enculturation of practice and discursive interactions and social construction of knowledge in the science classroom (Scott, Asoko & Leach, 2007). Whereas it is now recognized that cognitive and situated perspectives are to be integrated (Mason, 2007; Vosniadou, 2007), less attention has been given to how learning environment can be designed to bridge these two perspectives, and how to foster epistemological change and metaconceptual awareness mediated by collective discursive practice.

Recent research on intentional conceptual change emphasizes the role of learner's intentions, epistemological beliefs, motivation, and agency in knowledge restructuring (Sinatra & Pintrich, 2003). It also points to the need to design learning environments that encourage learners to integrate goal-directed strategies and to develop metaconceptual awareness for intentional conceptual change. A major related strand that has attracted much attention examines e*pistemological beliefs* or beliefs about the nature of knowledge, knowing and learning (Hofer & Pintrinch, 2003). Increased research evidence has shown how these beliefs can facilitate or constrain student understanding, reasoning, thinking, and science learning. For example, research indicated that a belief about knowledge as certain and simple was negatively correlated with conceptual change learning from refutational text. Students' immature beliefs about learning and knowledge are related to difficulties in their conceptual understanding (Qian and Alvermann, 2000). Students who hold more sophisticated epistemological beliefs are more likely to consider conflictual and controversial information; epistemological beliefs have been shown as a major predictor of argumentation (Mason & Scirica, 2006). For example, Stathopoulou and Vosniadou (2007 examined the relationships between physics-related epistemological beliefs and physics conceptual understanding amongst 10th grade students. Whereas there has been much progress on examining the relationship between epistemological beliefs and science learning, most research conducted are correlation studies. There have been much fewer studies on how these beliefs can be modified and how they interact with conceptual change with social-constructivist instructional practice.

This study proposes the use of computer-supported collaborative learning environment to foster epistemological beliefs and conceptual change emphasizing the socio-cognitive dynamics of collective knowledge building. An emergent research strand on collaborative learning and social context is the use of computer-supported collaborative learning (CSCL) environment (Lehtinen, Hakkarainen, Lipponen, Rahikainen and Muukkonen, 1999). A prominent example of an educational approach using CSCL technology is "knowledge building" that emphasizes that knowledge as collective work of a community, and knowledge is improvable by means of discourse (Scardamalia & Bereiter, 2006). Knowledge building has been characterized as a third metaphor of learning as 'knowledge-creation' (Paavola, Lipponen, & Hakkarainen, 2004) that integrates the "knowledge-acquisition" (cognitive) and "participation" (situated) metaphors (Sfard, 1998). To support progressive discourse, Knowledge Forum (KF), a multimedia database constructed by students, was designed to support collective knowledge advances (Scardamalia & Bereiter, 1994). In knowledge-building communities, students make progress not only in improving their personal but also in developing collective knowledge through progressive inquiry. In knowledge building classroom, students posed cutting-edge problems, generated theories and conjectures, searched for scientific information, elaborated on others' ideas and co-construct explanation, and they collectively revised their theories mediated by in both Knowledge forum.

Research on knowledge building has shown how the approach can help restructure scientific discourse, foster deep understanding, and enhance inquiry-based scientific understanding (e.g., Caswell and Bielaczyc, 2001; Lee, Chan & van Aalst, 2006; van Aalst & Chan, 2007). Hakkarainen (2004) analysed young students' written productions in Physics posted to CSILE's database, and indicated that they engaged in epistemic agency and pursed explanation-driven inquiry and some of them moved towards theoretical scientific explanation. Zhang et al (2007) examined socio-cognitive dynamics examining epistemic agency of students in advancing their science knowledge for 5th and 6th grade students. Vosniadou and Kollias (2003) employed Knowledge Forum to foster the development of discourse and students' ideas, beliefs, and metaconceptual awareness. Whereas there are various studies examining science learning in knowledge-building classroom, thus far, there have been few studies that systematically examined knowledge building and conceptual change in more complex science domains. In particular, the relations of epistemological beliefs and metaconceptual awareness and conceptual change fostered through progressive discourse on Knowledge Forum need to be investigated.

Accordingly, this study investigated the roles of computer-supported knowledge-building inquiry in conceptual change and epistemological shift in the domain of chemistry among high school students in the Hong Kong context. The following research questions were addressed: (1) What were the effects of knowledge building on science learning and conceptual change? (2) What was the nature of epistemological beliefs, and what were the effects of knowledge building on epistemological change? And (3) What characterized students' engagement on Knowledge Forum, and what were the relationships among epistemological beliefs, knowledge-building process and conceptual change?

Method

Participants

Seventy-nine tenth graders in two science classes in Hong Kong participated in this study. There were 40 students in the experimental class and 39 students in the comparison class. The lessons were conducted in English and students in the experimental group wrote notes in English on Knowledge Forum. Both classes were taught by the same teacher, the researcher who had taught high school chemistry with over ten years and had used knowledge building pedagogy for 4 years.

Procedure and Design

This study employed a quasi-experimental pre-posttest research design. The study was conducted in the second semester of 2006-2007 (Feb to May). There were five chemistry lessons each week; each lesson was of 35-minute duration. In the experimental class, students learned electrochemistry in the knowledge-building collaborative environment using inquiry-based and collaborative activities. The students wrote computer notes and continued discussions with metacognitive reflections on the Knowledge Forum after class. The comparison class was instructed using the typical school approach with teacher explanation, class discussion and demonstration of animations and PowerPoint presentations. The other contextual variables were controlled to be similar for both groups including use of the same instructional topics, same textbook and reference materials, and conducting same experiments. Students in Hong Kong need to do homework: the experimental students wrote on Knowledge Forum whereas the comparison students worked on short questions, essays & reports.

The instructional design followed earlier studies using knowledge building in Hong Kong classroom (Lee et al., 2006). A four-phase instructional design was used: (a) Developing a collaborative culture where students were asked to put ideas to the public; (b) Knowledge-building inquiry: Knowledge Forum was introduced and students engaged in posing problems, making conjectures and hypotheses, co-constructing explanations, comparing different theories and explanations; (c) Deepening and Rise-Above: students deepened their understanding using rise-above notes and synthesized their understanding; and (d) alignment of assessment: students wrote reflections and e-portfolios identifying and capturing their own and community progress in knowledge building in their discourse.

Measures

Epistemological Beliefs Questionnaire. A questionnaire of 28 items was designed based on earlier work for elementary school science students (Conley et al., 2004). The scale was designed to reflect four dimensions of epistemology considered important to science learning including "Certainty", "Source", "Development" and "Justification". For scale development, pilot testing of items and interviews with experts and students were conducted for refining the scale. Then the questionnaire was administered to 270 students from Grades 7 to Grades 12. Factor analyses using Varimax rotation indicated three factors explaining 32.4% of variance, and the items correspond generally to what were expected on each dimension. Results indicated that items of Certainty and Source load on the same factor (Certainty-Source) contributing 12.1% of variance, Development contributed 10.7%, and Justification contributed 9.6%. Internal consistency of scale was acceptable: Certainty-Source (13 items, $\alpha = 0.72$), Development (7 items, $\alpha = 0.69$) and Justification (8 items, $\alpha = 0.68$). The scale was then administered to students at pre and posttests to identify their beliefs and to examine change.

Conceptual-Change Questions. A paper and pencil test was administered to both classes to identify conceptual difficulties, and to assess students' knowledge structures and understanding of the concepts of electrochemistry. The instrument consisted of open-ended items, multiple-choice and true/false items followed by giving reasons for the choices. Items were related to a) definitions of redox reactions, b) reactions in electrochemical cells, c) flow of electric current, d) functions of a salt bridge, e) reactions in electrolytic cells, f) identification of anode and cathode and their charges, g) working principle of zinc-carbon cell, h) cell potential, i) half-cell equations and overall redox equations, and j) reactions in short-circuit cell. The test items was validated by a university chemistry professor and an experienced chemistry teacher and piloted with 8 students. The test took 40 minutes to complete. The responses for the open-ended items were categorized into four levels of understanding.

Examination Questions. We also collected information from students' examination questions in chemistry from Grade 10 mid-year examination and Grade 10 final year examination. These questions can show if students could attain knowledge in chemistry as expected in the public examination.

Knowledge Forum Participation. Students' participation on Knowledge Forum was assessed using a software called Analytic Toolkit (ATK) that accompanied Knowledge Forum (Burtis, 1998). The software used server log data and provided quantitative indices of database usage including number of notes written, percentage of notes read, links to other notes, and use of scaffolds (thinking prompts), keywords and revisions. Quantitative indices are useful to provide an overview of student engagement in the forum (Guzdial, 2000) and ATK indices have been used in various studies on knowledge building to show student engagement (e.g., van Aalst & Chan, 2007).

Knowledge Forum Reflection. Students were asked to write about what they have learned on Knowledge Forum referring to their own and other students' notes. They were provided with scaffolds of 'theory-building' and'conceptual change' to help them reflect on how ideas are progressing and to help develop metaconceptual awareness. These responses were coded on a 5-point scale from simplistic to complex responses to track their understanding. This measure was based on earlier work similar to e-portfolio that examined students' engagement in knowledge building (Lee et al., 2006).

Knowledge Inquiry Scores. Students' questions on Knowledge Forum were examined and coded using a 5-point scale ranging from fragmented factual questions to general questions to explanatory questions. The scale was based on research on epistemological focus and inquiry of knowledge building (Hakkarainen, 2002; Lee et al., 2006). Inter-rater reliability of Knowledge-Building Reflection and Inquiry are currently being conducted.

RESULTS

Differences of Science Learning and Conceptual Change for Groups

Conceptual-Based and Examination-Based Questions

Students' conceptual understandings about electrochemistry were assessed using the overall written pre- and post conceptual change tests. Analyses of pretest scores indicated that there was no difference between classes suggesting similar knowledge levels. Analysis was conducted on gain scores and significant differences on gain scores were obtained favoring the knowledge forum class (M = 37.08) over the comparison class (M= 31.44), t (77) = 2.08, p = .04, with medium effect size ($\eta 2$ =.23). The results suggested that Knowledge building students outperformed the comparison students on conceptual change scores in electrochemistry. Analyses of students' pretest and posttest examination questions indicated no differences.

Table 1: Mean pre- and posttest % scores of conceptual and examination questions across groups.

	Knowledge Building (n=40)		Comparison (n=39)	
	Pretest	Posttest	Pretest	Posttest
Conceptual-Based Understanding	18.25 (6.92)	55.33 (11.33)	20.90(7.22)	52.34 (12.1)
Knowledge-Based Examination	74.3 (11.3)	78.2 (8.9)	73.2 (10.3)	74.9 (10.9)

Misconceptions and conceptual understanding

The content analysis of the chemistry achievement pre- and posttest items revealed that 13 misconceptions on electrochemistry were identified. The misconception statements and their percentages of two classes before and after the instruction are examined. Overall, both classes showed decreases and the Knowledge Forum students showed more decreases in several misconceptions.

Differences of Epistemological Change for Groups

Epistemological beliefs were measured on the three dimensions with a 28-item instrument. Items were rated on a 5-point Likert scale with higher scores indicating more sophisticated beliefs (Table 2).

Table 2: Pre- and posttest epistemological beliefs scores on overall and subscales across groups

Dimensions	KF class (n = 40)		Comparison class (n = 39)	
	Pretest	Posttest	Pretest	Posttest
Certainty-Source	3.41 (.48)	3.80 (.45)	3.43 (.38)	3.39 (.37)
Development	3.83 (.50)	4.29 (.41)	3.90 (.43)	3.86 (.50)
Justification	4.15 (.39)	4.29 (.39)	4.15 (.45)	4.21 (.38)
Overall	11.40 (1.10)	12.38 (1.02)	11.49 (.89)	11.47 (.88)

Reliability of 28-item scale : pretest standardized item alpha = 0.81; posttest standardized item alpha = 0.84

An independent sample *t*-test on pretest scores indicated no differences at pretest. Analyses of change in epistemological beliefs showed that the experimental students had significantly more changes than comparison students ($t(77) = 4.75$, $p<.01$) on overall scores. Further analyses indicated that significant differences were found on certainty-source ($t(77) = 4.47$, $p<.01$), and development ($t(77) = 5.48$, $p<.01$) indicating that Knowledge Building students made more changes from viewing knowledge as simplistic towards complex notions; and from seeing knowledge as static towards knowledge as extendable.

Characterization of Knowledge Building Processes

Participation Scores on Knowledge Forum (Quantitative Indices)

Preliminary analysis using the The Analytic Toolkit provided the degree of collaboration and pattern of social interactions among the students. There were 1024 notes written over the period of 4 months and the size of build-on trees included 97 small clusters (2-5 notes), 41 medium clusters (6-20 notes), 6 large clusters (21-40 notes) and 2 very large clusters (over 40 notes). Students wrote an average of 25.6 notes in the period. Although there was no norm, these ATK participation indices indicated high-level of participation and interaction. Analyses also showed that there was a high level of density indicating much interactions. The ATK indices were combined using factor analysis and two factors were extracted: *Factor 1* called *Participation* (notes created, scaffold uses and note revision) explained 35.29% of the variance, and *Factor 2* called *Collaboration* (notes read, keyword use and notes linked) explained 30.59% of the variance.

Reflection and Knowledge Building Portfolio

To illustrate how the knowledge-building approach may foster metaconceptual awareness, we provided an example of a student's reflection posted on Knowledge Forum. The quote in 'parentheses' is scaffolds (thinking prompts); we designed specific'conceptual-change' scaffolds in this study to foster metaconceptual awareness. The excerpt suggested that the student reflected on her puzzlement (uncertainty), noted earlier and current understanding, considered different ideas; used arguments for reasoning and examined various ideas posed by members of the community. Knowledge became an object of inquiry for analyses for developing a new understanding embedded in the social context of collective discourse.

Photosynthesis and Respiration

What I think earlier... Bernice suggested that respiration is a redox reaction, but I doubted since in the chemical equation I could not see a transfer of oxygen or electrons. C6H12O6 + 6O2 --> 6CO2 +6H2O Respiration is indeed a redox reaction (8 respiration as an example of redox reaction). (9 Photosynthesis) What I think now... We have to consider the alteration in oxidation numbers of the atoms instead of merely looking at the transfer of electrons or oxygen. The oxidation number of oxygen decreases from 0 to –2. [reduction].The oxidation number of carbon increases from 0 to +4. [oxidation] Since photosynthesis is simply the reverse of respiration, it is also a redox reaction. (10 Photosynthesis and respiration ARE redox reactions)

Argument Apple suggested that there is a transfer of oxygen, so they are redox reactions. For the case of photosynthesis, carbon dioxide loses oxygen but gains hydrogen to form sugar and water loses hydrogen but gains oxygen. Hermia also thinks that they are redox reactions, and she (11 My guess to respiration as redox reaction) suggested that there might be other definitions of redox besides the transfer of electrons and oxygen. (12 PHOTOSYNTHESIS is a redox reaction!)

My new learning... I really gained a lot through this discussion, especially from Apple's explanation. It can be considered from a new orientation. I also learnt that the presence of life depends hugely on redox reactions, since respiration and photosynthesis are redox reactions themselves. I also found that a lot of biological changes in organisms are redox reactions, and this is a new discovery for me. An example haemoglobin in blood gains oxygen to form oxyhaemoglobin in oxygenated blood. The case of photosynthesis and respiration motivated me to find out more examples of redox reactions in daily life. (Linda)

Relationships among Epistemological Beliefs, Knowledge Building and Conceptual Change

Relationships Among Measures

We examined the relationships among various measures of epistemological beliefs, knowledge-building reflection and conceptual change. Correlations indicated that epistemological beliefs were significantly correlated with several pre and post- science learning measures (rs = .27 to .34, p<.05) suggesting that EB is linked to science learning. Significant correlation were also observed between knowledge building reflection (metaconceptual awareness) with pretest epistemological beliefs (r = .33, p<.05) and with post EB development (rs = .36, p<.05). These findings suggest that students with more sophisticated beliefs are more likely to engage in deeper reflection. Further, there were significant correlations between knowledge building reflection and inquiry with conceptual change learning (rs =. 39-.46, p<.05). These finding indicate some positive correlations among epistemological beliefs, metaconceptual awareness (reflection) and conceptual change.

Table 3: Correlations of Epistemological Beliefs, Forum Participation, Forum Collaboration, Reflection, Portfolio, Examination, and Conceptual Scores

	2	3	4	5	6	7	8	9	10
1. Pre-EB	.47***	.20	-.11	.33*	.24	.27*	.23*	.26*	.12
2. Post-EB		.17	.23	.25	.14.	.28*	.34**	.18	.25*
3. Forum participation			.00	.65***	.31(*)	.16	.20	.42**	.36*
4. Forum collaboration				.08	.12	.36*	.19	.10	.18
5. KB Reflection					.42**	.39*	.45**	.24	.42**
6. KB Inquiry						.43**	.44**	.13	.46**
7. Pre-Examination							.72***	.32**	.49***
8. Post-Examination								.27*	.54***
9.Pre-Conceptual									.23*

Note: 1. Pretest epistemological beliefs; 2.Posttest epistemological beliefs; 3. Knowledge-Forum Participation; 4 .Knowledge-Forum collaboration; 5. Reflection; 6. Inquiry; 7. Pretest exam; 8. Posttest exam; 9. Pretest conceptual question; 10. posttest conceptual questions

Contribution of Knowledge Building Process to Conceptual Change and Belief Change

To provide a more coherent picture, we examined the contribution of various measures to conceptual change. Hierarchical regression analyses were conducted on posttest conceptual-based question scores, first entering pretest conceptual question scores, followed by knowledge building reflection, followed by epistemological beliefs. Results indicated that prior conceptual-based scores was a significant predictor (R =.48) that explains 23% of variance of posttest conceptual scores. When knowledge-building reflection was added to the analyses, multiple R increased to .58 that explains another 10% of variance with significant change. When epistemological beliefs were added, there were no increased variances explained. These findings indicate that over and above prior knowledge, metaconceptual reflection on Knowledge Building contributed to conceptual change. The same patterns of results were obtained when we used kb inquiry scores as the predictor.

Table 4: Prediction of Post-test Conceptual Scores Using Pretest Conceptual Scores, EB, and Reflection

	R	R^2	R^2 Change	F Change
Pretest conceptual scores	.48	.23	.23	11.45**
Knowledge Building Reflection	.58	.33	.10	5.60*
Epistemological Beliefs	.58	.33	.00	.03

We also examined epistemological belief as dependent variables to examine what would contribute to its change. Hierarchical regression analyses showed that pretest epistemological beliefs was a significant predictor (R = .51) explaining 26% of variance. We found that the quantitative knowledge-forum collaboration index contributed to posttest EB over and above pretest beliefs. Students who participated on Knowledge Forum with high collaboration activities (notes read, notes linked, and keywords) appeared to shift more to sophisticated beliefs over and above pretest beliefs.

Table 5: Prediction of posttest beliefs using pretest beliefs and Knowledge Forum participation

	R	R^2	R^2 Change	F Change
Pretest epistemological beliefs	.51	.26	.26	13.47**
Knowledge Forum Collaboration	.59	.34	.08	4.65*

Discussion

This study examined the roles of knowledge building on epistemological beliefs and conceptual change mediated by Knowledge Forum, a computer-supported collaborative learning environment. We first consider the effects of knowledge building approach on conceptual change and epistemological beliefs. We then consider explore possible interactions of epistemological beliefs, metaconceptual awareness and socio-cognitive dynamics of knowledge building for bringing about conceptual change.

Conceptual Change and Knowledge-Building

The first research question examined the instructional effects of knowledge building pedagogy on high-school students' scientific understanding and conceptual change. The results indicated that experimental students and comparison students had similar levels of prior knowledge and patterns of misconceptions before instruction. After instruction, experimental students made more gains than the comparison students on conceptual-change questions. Detailed analyses of types of misconceptions indicated that both groups made improvement, but the experimental students reduced more misconceptions in electrochemistry. These findings support the increased emphasis on social construction of science knowledge, and specifically it supports the notion that collective knowledge building mediated by Knowledge Forum have positive effects on learning science Our results are consistent with earlier research on knowledge building discourse in elementary students' scientific understanding (Hakkarainen, 2004; Zhang et al., 2007). We extended earlier research to conceptual change for high-school students in a complex domain of electrochemistry; we examined conceptual change more systematically designing tasks that tapped students' misconceptions. We provided some preliminary evidence suggesting how knowledge-building involving progressive and problem-based inquiry in a community could possibly foster students' conceptual change.

Nature and Change of Epistemological Beliefs

The second research question investigated the nature of students' epistemological beliefs, and to examine the effects of knowledge building on epistemological beliefs with knowledge-building approach. We constructed a scale on student epistemology focusing on domain-specific beliefs about chemistry; such an approach aligns with current emphasis of domain and context-specific beliefs. Three factors were identified including certainty-source, development, and justification; these factors are consistent with the ones identified with earlier research on epistemology (Conley et al., 2004). Comparison of pre- and posttests indicated that experimental students made more shifts on their overall epistemological beliefs than comparison students; specifically, they gained more shifts on "certainty-source" and "development" of knowledge, indicating that experimental students now tend to view knowledge not as discrete facts but complex knowledge that does not only reside in external authority but can be constructed and derived from multiple sources. The findings also suggest that knowledge-building students are more likely to hold the view that knowledge is not static but changeable and extendable over time.

Such beliefs seemed highly consistent with the kinds of beliefs to be fostered in a collaborative knowledge-building community – When students work together to construct new understanding, they would be able to see knowledge as constructed collaboratively and that knowledge can be advanced, improved and extended. There is considerable work on roles of epistemological beliefs in science learning (e.g., Hofer & Pintrinch, 2003). We extended current research examining how epistemological understanding may be changed over time with socio-cognitive dynamics of the knowledge-building environment.

Knowledge Building, Epistemological Beliefs, and Conceptual Change

The third research question examined the nature of knowledge building and the interactions of epistemological beliefs, knowledge building process, and conceptual change. We first assessed knowledge building process to examine students' engagement in reflective and intentional learning on Knowledge Forum. Using quantitative indices derived from Analytic Toolkit, we found that students were generally actively involved in Knowledge Forum. Although there were no norms for online forum involvement, the quantitative indices as compared to common patterns of online forum (Lipponenen et al., 2003) suggest that students working on this Knowledge Forum were participating actively; such interactions and collaboration on the forum would be needed to provide the foundation for students to work together for deep reflection.

We also used other qualitative indices including 'reflection notes' to probe into students' metaconceptual awareness. As the excerpt showed, students were prompted to reflect on their puzzlement and gaps of understanding; they referred to arguments and evidence to help them revise their understanding; and they reflected on new understanding. These reflection notes are similar to our design of e-portfolio that served both purposes of assessment for tracking and scaffolding knowledge-building (see van Aalst & Chan, 2007). When working on Knowledge Forum, students were engaged in co-constructing and revising their understanding; these reflection helped to capture the knowledge-building process. Students were reflecting on individual understanding in the context of how others have helped them understand; their reflection notes also provided the kind of knowledge artefacts for improvement of understanding. These reflection suggest how students were developing metaconceptual awareness reflecting on the relations between their 'naïve' conceptions and new understanding and deepening their epistemology supported in the social context.

The third research question also examined the relationships among epistemology, knowledge building engagement and reflection, and conceptual change. Epistemological beliefs were correlated with several measures of pre- and post-test exam and conceptual-change question scores. We also found that students with more sophisticated beliefs were engaged in deeper reflection and inquiry. These patterns are consistent with current research on roles of epistemological beliefs on learning and conceptual change (e.g., Mason & Scirica, 2006; Qian & Alvermann, 2000; Sinatra & Pintrich, 2003). When different variables were examined using regression analyses, knowledge-building reflection significantly predicted conceptual change over and above effects of prior knowledge. Epistemological beliefs were not a significant predictor after controlling for prior knowledge. The same patterns were obtained using a different knowledge-building measure 'inquiry'. These findings suggest the important role of knowledge-building process contributing to deep conceptual understanding. When students inquire and reflect on their understanding in the context of community knowledge they may advance in their individual and group learning that predicted subsequent posttest conceptual change.

For epistemological change, it is interesting to note that the extent to which students engaged in Knowledge Forum collaborative activity (reading and linking more notes) contributed to belief change. It is possible that students who read more and made more links and references to others' notes might see knowledge as more complex and extendable. Although epistemological beliefs were not a predictor of conceptual change probably due to the limited time of instruction, the patterns of results are generally consistent with results indicating relations of beliefs with reflection both illustrating goal-directed intentional learning strategies. Currently, we are conducting interviews to probe more deeply into the nature of epistemological change to understand more about its relations with metaconceptual awareness and conceptual change.

Implications, Future Directions and Conclusions

These findings suggest an emerging picture of how knowledge building may foster conceptual change with evolving metaconceptual and epistemological shifts. We propose that knowledge building may help integrate cognitive and social perspectives of learning (Vosniadou, 2007); it emphasizes objectified knowledge that can be examined, revised, and improved with the collective efforts of the community. We investigated students' *cognitive* understanding and shifts in misconceptions; we also emphasized the role of *social* and discursive discourse as students engaged in collaborative inquiry on the forum Further, analyses of student's reflection suggest how individual and collective aspects of learning can be integrated mediated by progressive discourse. Students were reflecting on how naïve conceptions can be revised with new information as they pondered on the relations of old and new understanding. Their reflections are contextualized as they enculturate the practice of a community of scientists. Their reflections and metaconceptual awareness go beyond individual but involves "social metacognition" as students reflect on both personal and community understanding. Their evolving knowledge can be objectified and examined and fostered as they participate, interact, and enculturate into the practice of a knowledge building community..

In conclusion, this study employed a knowledge-building framework to examine and to foster cognitive and epistemological changes scaffolded in a knowledge-building environment. Our findings shed light on the nature of beliefs and how they may be modified over time with knowledge building approach. We showed how the design of computer-supported knowledge building environment may have positive effects on conceptual and epistemological changes, and we showed the contribution of metaconceptual awareness to conceptual change. Knowledge Building is an instructional approach that may scaffold conceptual change; and it also provides the environment that may provide rich data for investigating how change in epistemology, intentional learning, metaconceptual awareness interact with conceptual change.

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