

Developing Productive Discourse Through Collective Inquiry of Knowledge-Building Principles

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Abstract: This study investigates how secondary school students inquired into knowledge-building principles and engaged in meta-talk for productive knowledge building. The study involved a class of Grade 10 students in Hong Kong, working on collective inquiry in Art and Design using Knowledge Forum® (KF), and reflecting on their discourse, using knowledge-building principles. A key design involved students writing on KF inquiring into knowledge-building principles and meta-talk on the processes. Results indicated that the students engaged in productive online discourse on both domain and discourse understanding progressively. Classroom analyses suggested how students engaged in meta-talk and inquiry into principles with corresponding change in the knowledge about discourse. The implications of scaffolding students' inquiry of principles in a knowledge-building environment are discussed.

Introduction

Dialogue, as a talk that combines the sharing of ideas with meaning making, acts as a medium for developing students' learning and thinking (Mercer & Littleton, 2007) and specifically important for improving ideas and creating new knowledge (Bereiter & Scardamalia, 2016). It provides a theoretical framework for computer-supported collaborative learning (CSCL) (Stahl, Cress, Ludvigsen, & Law, 2014). Knowledge building (KB), as a CSCL model, aims to advance community collective knowledge via idea-centered discourse (Scardamalia & Bereiter, 2014). Scardamalia and Bereiter (2014) argued that knowledge building will fail if knowledge-building dialogue fails; therefore, the essential goal in a knowledge-building environment is to help students take collective responsibility for developing knowledge-building dialogue. To support such dialogue, Knowledge Forum® (KF) has been designed as a collaborative discourse space in which students can develop discourse from a knowledge-building perspective, with the aid of its various technological functions (e.g., build-on others' ideas, linking and rise-above ideas, and revise ideas, etc.) and metacognitive scaffolds (e.g., "I need to understand", "My theory", "A better theory"). Further, Scardamalia (2002) proposed twelve principles to characterize knowledge building and to guide teachers and students to engage in a principle-based instead of procedure-based learning environment; these principles include epistemic agency, improvable ideas, community knowledge, idea diversity and so forth that are the essential themes of knowledge building. While it is a taken-for-granted theme but limited systematic study of what such understanding of principles would influence students' productive discourse engagement and how to scaffold such understanding is not well examined. Many KB studies assert the importance of principles (van Aalst & Chan, 2007; Zhang et al., 2018), but this is one of the few to develop a systematic design focusing on students' understanding and collective inquiry of KB principles based on their authentic practice and work thereon rather than their declarative knowledge of a list of principles.

Examining principles as conceptual and epistemic artefacts for inquiry is critical for knowledge work as they are the epistemic criteria for knowledge generation. Many studies have been analyzed and scaffolded productive KF discourse (Chan, Lam, & Leung, 2012; Niu & van Aalst, 2009; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007), but how students understand the nature of discourse and specifically, how it needs to be linked to KB principles and its influence on students' productive discourse engagement has not been understood. In related research, Wegerif (2001) developed dialogic pedagogy for teaching of dialogic skills and ground rules (e.g., all relevant information is shared), to help students develop meaningful discourse for problem solving. Similar to the teaching of ground rules to provide students' explicit knowledge about dialogue, we propose that students need to have an understanding of the nature of discourse; students' epistemic understanding of knowledge building and principles would be important in students' creative work for productive discourse. This study addresses this issue, as part of a large study that examining the design, process, and roles of a meta-talk computer-supported knowledge-building environment for students' understanding of discourse and knowledge advance. In a preliminary study, we reported that students' understanding of discourse could influence their taking collective responsibility in the community discussion. This study examines further on how students' collective inquiry of principles can be scaffold and its relation to knowledge-building dialogue engagement, especially for low-achieving students who might have difficulties in engaging in higher-order thinking skills (Zohar et al., 2001) and have less opportunity to take responsibility to engage in productive

discourse as teachers believe that low-achieving students need more direct instruction (Zohar & Dori, 2003). Overall, this study designed an environment and examined the role of design on students' productive KF discourse and increased collective responsibility; how students reflected on their discourse and engaged in meta-talk and build knowledge about KB principles; and the influences of these processes on their subsequent understanding on knowledge building. Specifically, three research questions were addressed: (1) Did students engage in productive KF discourse with increasing collective cognitive responsibility over time? (2) How did the dynamics of classroom meta-talk and processes scaffold students' collective inquiry of principles? And (3) How was students' understanding of the nature of discourse reflected in interviews and what were its relations to the KF knowledge-building dialogue engagement?

Methods

Design the knowledge building meta-talk environment: collective inquiry of principles

This study drawn upon the data from students' KF discourse, classroom talk, and interviews involving twenty-one Grade 10 students from a low-performing school based on students' public examination results studying the topic on "Green Design" participated in the study over one semester. The key design was to include different KF views and one specifically devoted to inquiry into KB principles. Specific designs included: (1) KB Wall and ideas development trajectory (students posted and shared their initial ideas on a wall with others' build-on, followed by a classroom reflection) (Weeks 1-3); (2) authentic problems and KF inquiry (students proposed authentic problems by watching videos on "design and earth environment" and group discussion, followed by KF inquiry) (Weeks 4-6); (3) deepening inquiry through comparing discourse (students worked in groups to generate knowledge about their prior understanding of discourse by comparing their KF discussions) (Week 7-9); (4) connecting students' understanding and KB principles (students connected and matched their prior understanding on discourse with the epistemic criteria for discourse that are the KB principles) (Weeks 10-12); and (5) collective inquiry and reflection (students wrote portfolio notes on KF to reflect on their collective understanding of principles) (Weeks 13-15).

Data Analysis and Results

RQ1. Examining KF engagement and inquiry into principles and domain knowledge

Students' KF engagement and change towards connectivity and collective responsibility

The first research question examined student engagement and inquiry into domain knowledge and principles and change over time. Primarily, the key question is can students engage in productive discourse? We first conducted KBDeX (Oshima et al., 2012) analysis to explore how discourse network changed between the Period 1 (before classroom meta-talk on principles - Week 1 to 6) and Period 2 (after classroom meta-talk on principles - Week 7 to 15). Students' KF notes were exported into KBDeX, which produced three networks of analysis-students, discourse, and keywords-based on the selected conceptual keywords. We examined the discourse network change. As Figure 1 shows, the discourse network is more integrated with few fragmented notes in Period 2 than Period 1. In Period 1 (1a and 1c), there are many separate notes (red) remained outside the main cluster (yellow). In Period 2 (1b and 1d), the discourse network was more integrated, with fewer fragmented notes (red). This suggests that in Period 2, students engaged in KF discourse in a more cohesive discussion and productively with sustained collective knowledge advancement than Period 1.

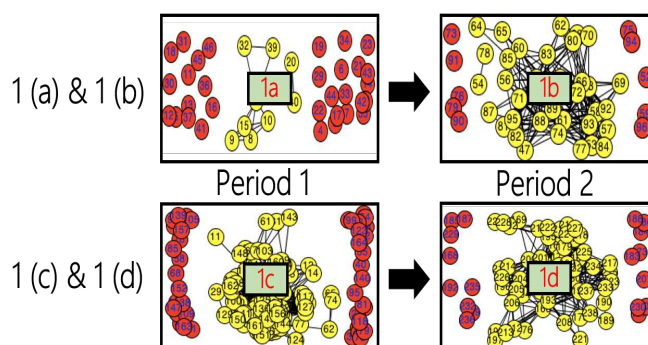


Figure 1. KF discourse network change - principles (1a&1b) and domain discussion (1c&1d) in two periods.

Inquiry thread analysis of online KF discourse

Further to overall network analyses, content analysis was conducted to examine how students engaged in productive knowledge building. The KF notes were parsed into threads based on the conceptual problems (Zhang et al., 2009), with 14 such threads being identified (e.g. “design and environmental development”). Individual notes were coded within each inquiry thread, using a coding scheme based on a theory- and data-driven approach and including questions (Hakkarainen, 2003), contributions (Chuy et al., 2011), and meta-discourse (Table 1). As Table 2 shows, the results suggested that students asked sustained questions for deeper inquiry, enriched and improved on ideas, and used elaboration to support those ideas; in addition, students also engaged in meta-discourse by referring back to previous discussions to synthesize what had been discussed and rise-above the inquiry process using reference function incorporating other community ideas. A second rater coded 30% of data, and the inter-rater reliability was .92 for questioning, .86 for theorizing, and .87 for community (Cohen’s kappas).

Table 1: Coding scheme for analyzing KF discourse in inquiry threads

Codes	Sub-codes	Description	Examples
Questioning and Identifying Gaps	Fact-seeking	Questions on seeking factual information	What is the definition of design?
	Explanation-seeking	Questions on seeking open-ended responses with explanation	How to use design to solve environmental problems?
	Sustained inquiry	Asking further questions based on previous notes or ideas and make the discussion deeper	How can a design be regarded as a good design if it cannot solve any problems? (A question asked based on a previous note).
Theorizing and Improvable Ideas	Simple claim	Simple (dis)agree or repeat a statement	I agree with the idea.
	Proposing an explanation	Proposing a theory that explain certain phenomena for the first time	Design can improve the quality of our life.
	Enriching an explanation	Enriching a theory with elaboration and new information	A good discourse needs to have a good question first...The question can be solved through discussion and new questions would emerge...
	Supporting an explanation	Supporting an already existing theory proposed by another student and providing a justification	It could be or not, but we can learn new knowledge and improve ideas through communication.
	Improving an explanation	Improving an already existing theory through elaboration, specifying details and using new evidence	A good discourse refers to a community discussion rather than individuals expressing ideas. Students can build-on other’s ideas...we can acquire valuable ideas through discussion.
	Challenging	Challenging or disagreement an existing ideas proposed by other students	What you mentioned about the use of design...but I do not think we can solve all the problems by our artifacts design.
Meta-discourse	Connection	Reference to their own or others’ notes, or quoting extra sources to advance understanding	A good discourse needs to have diverse ideas, as proposed by [redacted] (“diverse ideas for discourse” S077)...we also need to develop a productive discourse with meaningful ideas.
	Rise-above	Refer back to what has been discussed and ask a new question for monitoring the inquiry process and advancing the discussion; or generating an explanation or evaluation to appraise their own or others’ notes	Through our discussion, we discussed the idea of design...by [redacted] (“design” student S089) and design can be developed together with the society by [redacted] (“design and development” student S005) What we need to discuss further is how can the design be improved?
	Synthesize	Coordinating and integrating collective ideas from previous discussion with a reflection	[redacted] (“a good discourse needs to have diverse ideas...”) by student084 [redacted] (“...we need to querying others’ ideas”) by student011. In this discussion, they think that students need to participate actively with diverse ideas...

Table 2: Number of different codes in inquiry threads

Thread	Fact	Explain	Sustain	Simple	Propose	Enrich	Support	Improve	Connect	Rise	Synthesize
#1	0	5	7	4	18	6	1	1	3	1	0
#2	0	4	5	4	14	5	4	3	7	2	2
#3	1	4	8	2	5	7	3	2	3	2	0
#4	1	2	12	2	19	7	2	0	8	1	0
#5	0	2	9	2	5	1	3	4	4	2	4
#6	0	4	1	1	4	0	1	0	0	0	0
#7	0	4	3	0	5	1	2	2	2	2	2
#8	0	3	5	3	7	4	2	4	3	0	1
#9	0	0	1	0	4	4	9	0	0	2	3
#10	1	0	1	0	2	1	0	1	0	0	0
#11	0	1	5	2	9	1	0	3	1	1	1
#12	0	2	6	0	6	9	3	4	10	2	8
#13	0	2	3	0	1	2	2	0	0	0	0
#14	0	3	2	0	8	10	0	1	0	0	3
Total	3	36	68	20	106	58	33	25	41	15	24
Mean	0.21	2.57	4.86	1.54	7.57	4.14	2.36	1.79	2.93	1.07	1.71
SD	0.41	1.49	3.2	1.45	5.37	3.16	2.16	1.52	3.17	0.88	2.19

To understand how students' discourse changed, the KF notes were divided into two periods-before and after the classroom meta-talk on KB principles. We calculated the frequency of high-level discourse moves (Table 3), and analyses were conducted to examine whether students engaged in more productive discourse from Period 1 to Period 2. Paired sample t-test indicated that there were significant increases from Period 1 to Period 2 in terms of sustained inquiry, $t(20) = 2.597, p < .05$; enriching an explanation, $t(20) = 3.525, p < .01$; supporting an explanation, $t(20) = 3.068, p < .01$; improving an explanation, $t(20) = 2.958, p < .01$; connection, $t(20) = 3.118, p < .01$; rise-above, $t(20) = 2.366, p < .05$; and synthesize, $t(20) = 2.915, p < .01$. The results suggest students' discourse moves changed to a more knowledge-building approach, which the students engaged more in supporting and improving their ideas and explanation. Further, students also engaged in a reflection approach with collective ideas coordinating and monitoring collective ideas for deeper inquiry. Overall, the results showed that students engaged in a more productive knowledge-building discourse over time.

Table 3: Frequency of high-level notes in Period 1 and Period 2

High-level discourse	Period 1 (Week 1 to Week 6)	Period 2 (Week 7 to Week 15)
Explanation-seeking question	20	16
Sustained inquiry	29	39
Enriching an explanation	28	30
Supporting an explanation	8	25
Improving an explanation	2	23
Challenging	4	10
Connection	9	32
Rise-above	0	15
Synthesizing	0	24

RQ2. How did students engage in meta-talk for collective inquiry of principles?

This study also analyzed themes identified from the classroom processes to investigate how students could engage in productive KF discourse (RQ1). We discussed the design and examined how students engaged in collective inquiry of principles mediated by classroom meta-talk for knowledge building.

Scaffolding principle-based understanding with KB Wall idea reflection and KF inquiry

Generating productive discourse is key to knowledge building for community knowledge advancement. In the knowledge-building classroom, scaffolding is initially used to help students engage in a principle-based collaborative learning environment. The knowledge-building wall (KB Wall) (Fig 2a), as a physical visualization of KF, provides an opportunity for students to publish their ideas by posting their questions, and to build-on each other's ideas (the lines represent the build-on relations). Further, to scaffold students to track their idea development on the KB Wall, students were asked to write rise-above portfolios to reflect on how their

ideas improved with referencing the community's ideas from the KB Wall (Figures 2b and 2c). Students shared their rise-above portfolio and refined their ideas through classroom discussion while continuing their discussions on KF (Fig 2d), both in terms of domain knowledge and understanding of principles. KF provided a collaborative space for improving ideas and sustaining inquiry through idea-centered discourse. This KB Wall and rise-above portfolio writing experience might help students engage in the sense of principles of improvable ideas, rise-above, epistemic agency, and community knowledge.

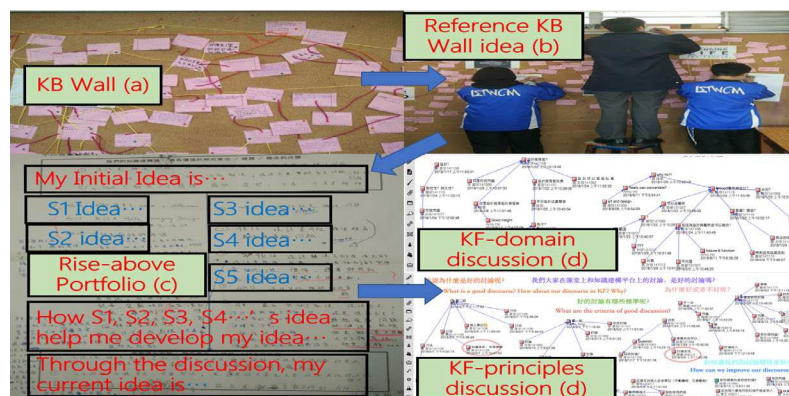


Figure 2. KB Wall (a) - Rise-above portfolio (b&c) - KF inquiry (d).

Comparing KF discourse for developing criteria of knowledge building discourse

Understanding the knowledge-building principles, which are the epistemic criteria for the nature of discourse and standards of knowledge work is important for producing knowledge-building dialogue. After discussing matters on KF for a period of time, students started to reflect on their discourse, using criteria for developing of a good discourse. Two discourse moves that students generated in KF were provided (Fig 3a), along with a designed prompt sheet (Fig 3b). Students drew mind map, which is one of the scaffold to help low-achieving students to visualize their ideas, as a way to explain their comparison and understanding of the discourse moves (Fig 3c). They shared their mind map with the class, followed by a classroom discussion. The following excerpt illustrates how criteria for good discourse were developed by students through their KF discourse reflection. The discussion suggests that these students were not only described the structures of the threads, they also assessed the quality of the notes (*they have a summary note in the discourse move*) and noted the strategies for improving a discourse (*we can make a summary to reflect...and integrate the different ideas together*).

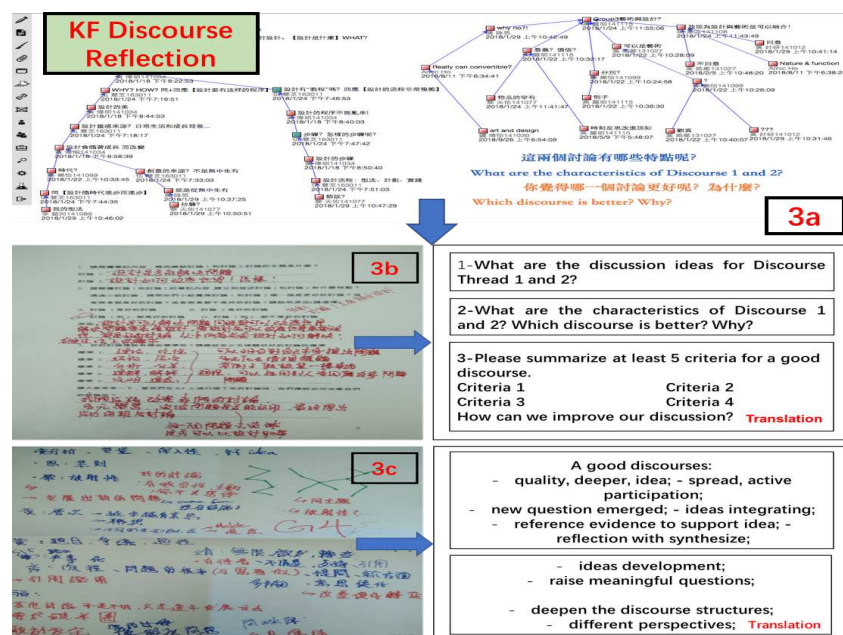


Figure 3. Prompt sheet for criteria generating (3b) and Mind map on discourse comparison (3c).

- T(Teacher) Can anyone explain your understanding of a good discourse based on your community KF discussion comparison?
- S7(Student) We compared two discourse moves that we proposed in KF...The first discourse move was more **singular with a few straight build-on lines**...The other discourse move was **more diversified with spread build-on lines**...their **idea was getting deeper and had the potential to produce a new question to sustain the inquiry**...
- T Good point! Can anyone add more?
- S7 We can **make a summary to reflect on what we had discussed**...
- S8 ...The **“diverse” refers to the idea development**...
- S9 They had a summary note in the discourse move; the **“summary” was one of the criteria we proposed for a good discourse**...

Identifying and categorizing epistemic criteria linked to principles

Another aspect of scaffolding students' understanding of principles is the linking the criteria generated by students (learner criteria) and the knowledge-building principles (expert criteria). Students constructed mind maps that categorized the learner criteria into different groups and linked them to “expert criteria” (Fig 4). For example, they put the “reference others’ idea” and “synthesizing and reflection” into one group. Next, they started to link these learner criteria to KB principles and found some of the principles were overlapped different groups. Different arrows are connected the criteria generated by students and the KB principles. Students were asked to explain the reasons for their categorizing and linking. The teacher invited students to explain the categories and links they developed and the following example showed how students explain the reasons (*reflection is a type of assessment that can help us to revise and improve ideas*...) and gradually engaged in a deeper discussion in illustrating how to improve a discourse with using these principles as strategies.

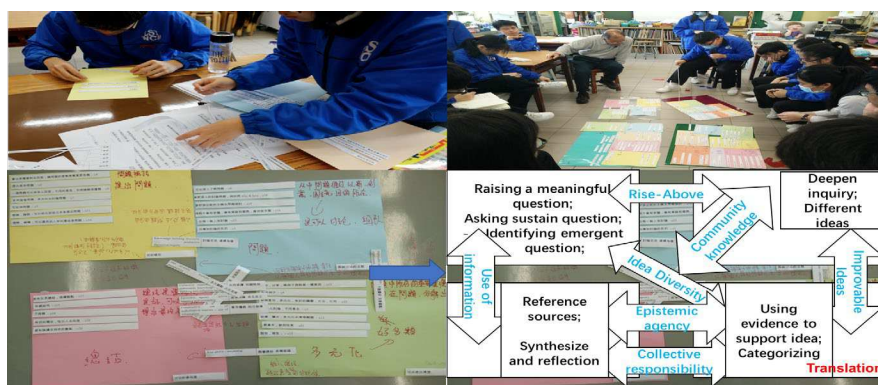


Figure 4. Criteria categorizing and principles matching and Mind map with translation.

- T Can anyone explain how the connections you made between your criteria and the principles?
- S1 We put the principle “**improvable ideas**” here because the **question in this discourse move made the ideas developed**... ..
- S3 Yes, **reflection is a type of assessment that can help us to revise and improve ideas in the discussion**.
- S1 For the “**collective responsibility**”, we connected it the **contribution**.
- T Can you explain a bit more?
- S4 It refers to that everyone should take the responsibility **to join the discussion and contribute to the community**...

Collective inquiry with portfolio notes on principles understanding

Students continued to work on KF and wrote portfolio notes reflecting on their understanding on the nature of good discourse and linking it to KB principles. Figure 5 shows an example of KF view for collective inquiry on principles and a portfolio note using reference function using to explain their understanding.

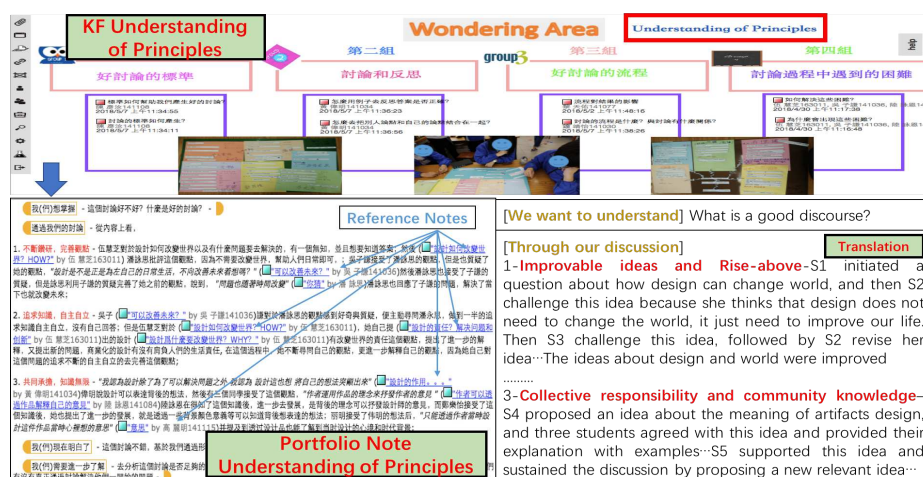


Figure 5. Portfolio note for reflection on understanding of discourse with translation.

RQ3. Deepening understanding of principles and relations with KF engagement

The third research question examined the role of design and processes on students' understanding of discourse and the shift towards principles as epistemic criteria. We examined students' open-ended questions and interviews and we also examined how their understanding was related to their productive KF discourse.

From viewing good discourse as acquiring an agreement to viewing it as improving ideas

Qualitative analysis of students' interviews showed that the changes in their understanding of discourse between their pretest and posttest interviews. Students initially thought the purpose of discourse was only to get an agreement or a correct answer, after the program, their understanding of discourse changed to reflect a KB approach. Student LYE thought the major theme of discussion was to get answers in the pretest; however, in the posttest, she started to think that the purpose of discourse was to improve ideas through sustained discussion.

Pretest Interview	"A good discussion is asking a question together...to get answers through discussion."
Posttest Interview	"A good discussion <i>connects ideas together for deeper discussion</i> ...The initial question for this cluster of discussion was "what is design?"...The <i>idea about design continued to improve through the discussion</i> ."

From viewing good discourse as a process of merely discussion to viewing it as rise-above

To engage in a productive discourse, students need to querying ideas, coordinate ideas with reflection and rise-above for further inquiry. Interviews showed that students initially regarded discourse as a process of expressing and accepting ideas, rather than one involving build-on, challenging, and reviewing. However, after the program, student ZLY had an awareness of the importance of reflection and synthesizing.

Pretest Interview	"A good discourse is expressing ideas and accepting others' ideas."
Posttest Interview	"A good discussion requires everyone to <i>reflect and synthesize these ideas in order to see if there any new problems emerged</i> ...We have different ideas in a discussion, and it is good to <i>generate new questions for further discussion</i> ..."

From viewing good discourse as sharing of ideas to advancing community knowledge

To create knowledge, students not only need to understand the sharing of ideas, but also to distinguish the difference between knowledge sharing and knowledge creation. Students initially thought that discussion was for ideas sharing and problem solving only, and had no awareness of creating knowledge. Later on, when students engaged in the classroom meta-talk on principles, they started to emphasize on the difference between "sharing" and "creation". This excerpt shows that student GLM began to distinguish the two metaphors.

Pretest Interview	"Everyone share ideas...I am not sure whether we can create new knowledge..."
Posttest Interview	"A good discussion needs to <i>be a continuous build-on</i> . We discussed " <i>knowledge contributor</i> " and " <i>knowledge creator</i> "...for <i>building on to advance community knowledge...and create new knowledge through discussion</i> ..."

Students' interview responses were coded into three levels. Quantitative analyses indicated that students' understanding of discourse by interview correlated with their productive KF discourse moves, in terms of sustained inquiry ($r=.556, p<.01$), enriching an explanation ($r=.722, p<.01$), supporting an explanation ($r=.439, p<.05$), improving an explanation ($r=.738, p<.01$), challenging ($r=.485, p<.05$), connection ($r=.633, p<.01$), rise-above ($r=.467, p<.05$), and synthesizing ($r=.754, p<.01$). The findings suggested that students with deeper understanding of the principles also seemed more likely to be engaged in KF productive discourse.

Conclusion and implications

The study has examined how students' collective inquiry of KB principles for developing productive discourse can be scaffold and its relationship to productive KF discourse. Analysis of KF discourse using KBDeX indicated how students' discourse became more coherent and productive in Period 2, after they inquiring on the KB principles in the classroom meta-talk, reflecting on their KF discourse and linking it to KB principles. Classroom design and processes suggested how students can engage in collective inquiry into KB principles to support their knowledge-building work. We also characterized students' understanding of principles as it related to their productive KF discourse engagement and examined relations between their understanding of principles with KF collective inquiry. Many studies have proposed the importance of KB principles, however, no systematic work were conducted on students' collective inquiry into principles using both KF and classroom discourse. This study has shown how students authentically worked on principles that were explicitly integrated with their KF discourse, and the possibility of changing students' understanding of the nature of discourse by linking it with principles. In sum, this study is particularly important, as little research has focused on how students' collective inquiry of KB principles can be scaffold to help them engage in productive discourse.

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