Developing Productive Discourse among Low Achievers in a Knowledge Building Environment

Yuyao Tong, Carol K.K. Chan, and Jan van Aalst
tongyuyao2016@gmail.com, ckkchan@hku.hk, vanaalst@hku.hk
The University of Hong Kong

Abstract: This study investigates how an understanding of and engagement with productive discourse can be developed among low-achieving students in a knowledge building (KB) environment supported by Knowledge Forum®(KF). Participants were two classes of 9th Grade students in a Hong Kong secondary school. The design involves students engaging in productive discourse, talking about what constitute good discussion, and explicit reflection on their discourse using KB principles. Quantitative analysis shows that students improved more on their understanding of discourse than comparison student and engaged in discourse that become more productive over time. Qualitative analyses reveal how the low-achieving students engage in the classroom meta-talk to deepen their understanding of progressive views of discourse and knowledge building.

Introduction

Developing students' productive discourse has been the focus of recent research on learning, specifically in the learning sciences (Sawyer, 2014). Traditional teacher-student discourse, structured as initiate-response-feedback (IRF), has been the most frequent discourse pattern in the classroom (McNeili & Pimentel, 2010). However, under this rubric, students lack the opportunity to work collaboratively and to build-on each other's ideas for sustained inquiry and knowledge building. Consequently, there has been a growing interest in dialogical teaching in classroom discourse and teacher mostly as facilitator in developing a rich dialogic discourse (Chen, Clarke & Resnick, 2014; Hennessy et al., 2016). As discourse is epistemic in nature and central to knowledge development, how educators can help students develop a productive discourse and how knowledge-building discourse in classroom is manifested needs to be examined. Knowledge building (KB) is an educational model and pedagogy that has been examined in various domains and across grade levels, but relatively little work has focused specifically on low achieving students. Discourse development is often thought to be particularly challenging for low achieving students, as they tend to be perceived as unable to engage in high-level inquiry and thinking (Zohar, Degani, & Vaaknin, 2001). If the facilitation of classroom discourse is important for students to develop a complex, epistemic understanding of their inquiry and discourse, then a focus on enabling low-achieving students to engage in KB is even more pressing. How low-achieving students experience and perform in KB work in both classroom and online settings are thus important to examine. The purpose of the present study is to investigate the role of design in enhancing students' discourse understanding and to examine how productive discourse can be developed among low achievers.

Theoretical perspective

This study is based on the knowledge building (KB) educational model and pedagogy (Scardamalia & Bereiter, 2014). KB calls for the pursuit of idea improvement and collective responsibility. In the KB community, students engage in progressive discourse supported by Knowledge Forum® (KF), an online community platform. Students advance their community knowledge through sustained progressive inquiry using the embedded metacognitive scaffolds; (for instance, "I need to understand"). Ideas are regarded as a social product of the community (Scardamalia & Bereiter, 2014). However, students often engaged in disconnected and short-threaded discourse instead of productive discourse in their online discussion (Zhang & Chen, 2013). Just as discourse is central to researchers' and scientists' advancement of knowledge, students need to engage in purposeful discussion and explanation-inquiry driven discourse (Kuhn et al, 2011; Sandoval & Reiser, 2004). An increasing number of studies have been conducted to investigate students' discourse development and its role in learning, with many considering the role of discourse in students' understanding of science and students are scaffold to talk like scientists in interpreting data and relate data to theoretical claims (Sandoval, 2003).

From the perspective of KB, discourse is about progressive inquiry processes, understood to be a central epistemic practice in knowledge creation. As such, it is important for students not only to engage in discourse and inquiry, but also to understand why and how such discourse is important. KB proposed a set of 12 principles that are seen to be core to KB communities (Scardamalia, 2002), epistemic agency, collective responsibility, which together, provides epistemic criteria for students to better understand the development of

discourse. Engaging with discourse reflexively is seen to help students advance their epistemic understanding, to acknowledge that knowledge itself is evolving and extendable, and that it can be created collectively.

While helping students to understand productive discourse for epistemic growth and metdiscourse engagement are important (Yang, Chan, van Aalst, & Tian, 2016), it should not be assumed that students will spontaneously develop productive discourse, even in inquiry-learning environments (van Aalst, 2009). In science education, explicit reflection on the epistemic criteria of scientific model can help students to engage in the scientific inquiry and understand the nature of science (Pluta, Chinn, & Duncan, 2011). This is similar to the KB principles, in that it is important to help students and particularly low-achieving students to explicitly reflect on their discourse, rather than merely engaging in collective inquiry. Students need to engage in meta-discourse to reflect on their online talk and to identify deeper questions for further inquiry (Zhang & Chen, 2013).

Crucially, KB and other inquiry experiences are considered difficult for low-achieving students, who often have literacy problems and learning difficulties (Shen et al., 2007). They are perceived as being limited to low-level metacognitive strategies and unable to engage high-level strategies, making it difficult for them to plan, monitor, and reflect on their tasks and learning process and to highlight essential insights (Azevedo, Cromley, & Seibert, 2004; van Aalst, 2009). As such, it becomes particular important to help low-achieving students to develop productive discourse engagement using KB principles as epistemic criteria to monitor and evaluate their discussions. Earlier research provides some evidence of KB for low achievers (Yang et al., 2016), but the dynamics of classroom discourse and students' conceptions of discourse have not been investigated.

Overall, the goal of the present study was to design a KB environment that is focused on specifically on discourse development, reflection, and understanding for low-achieving students to help those students engage in productive discourse, and to examine the role of the KB environment on students' epistemic understanding, KF discourse development, and classroom productive discourse. Specifically, three research questions were addressed: (1) What characterize students' understanding of discourse, and how did they change after instruction? (2) What was the nature of KB discourse and to what extend did students engage in KF discourse? (3) How did students engage in the classroom discourse to reflect on their online talk?

Methods

Research context and participants
Two classes of 9th Grade students enrolled in a visual arts class at a Hong Kong Band-3 secondary school participated in the study. Secondary school are organized into three groups, from Band 1 (highest-achieving) to Band 3 (lowest-achieving) based on students' public examination results, and students in the present study are thus institutionally recognized as low-achieving students. The study was conducted in a classroom with students engaged in a KB environment augmented with explicit reflection (n=31). A comparison class, engaged in a regular KB learning without reflection and discourse design, was also included to provide additional data (n=32).

Pedagogical design
In this study, we designed a KB environment with an emphasize on understanding of discourse and explicit reflection to support student' production of knowledge and progressive productive discourse (Figure 1). An explicit reflection cycle was developed and implemented in the KB pedagogy (Chan, 2011).
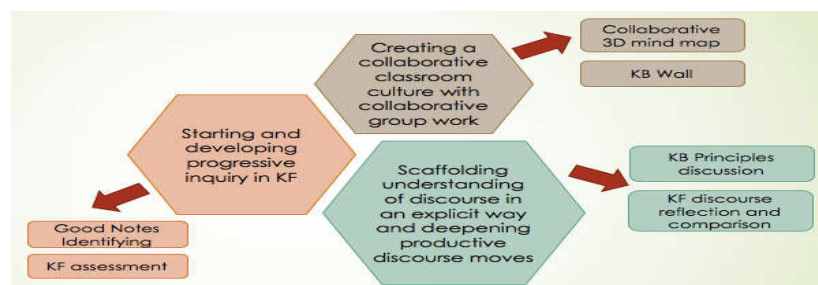

Figure 1. Pedagogical design.

(1) Creating a collaborative classroom culture with group work and ideas made public through a Knowledge Building Wall (KB Wall) (Figure 2) (Week 1-4). In developing a collaborative classroom culture, students first worked in groups to develop collective ideas through mind map and then presented ideas to the whole class; this was followed by creating a KB Wall to generate questions and build-on others' ideas in the

community; (2) Starting and developing progressive inquiry in KF with questions and ideas generated, as well, good KF notes identifying under teacher's scaffolding (Week 5-7). Students generated meaningful questions from the KB Wall to continue to inquiry on KF. After a period of discussion on KF, students were also asked to identify good notes based on their KB Wall and KF discussion; (3) Scaffolding understanding of discourse in an explicit way and deepening productive discourse moves with KB principles discussion and KF discourse reflection and comparison (Week 8-16). KF discussion and classroom talk were intertwined. The teacher started to help students to review on what they had learned, monitor their learning process, identifying core problems for further inquiry, and reflect on their KF discussion. The comparison class also went through the phase 1 to 2. But whereas the intervention group had KB Talk on discourse understanding and reflection of KF discourse moves, while the comparison group only continued to work in KF without intervention.

Figure 2. An example of students' mind map and KB Wall.

Data collection

Over a four-month period, students in both of the two groups inquired and discussed the topic of *what is art and arts appreciation*. Through this period, various data were collected including: (1) Pretest-posttest on discourse understanding. We collected and analyzed students' pre-posttests on their understanding of discourse with a written questionnaire to examine "what do you think is a good discourse?" (2) KF engagement. Students' online participation was examined Knowledge Building Discourse Explorer (KBDeX) (Oshima, Oshima, & Matsuzawa, 2012); (3) KB discourse. We conducted content analysis to examine students' written in KF and used individual notes as the unit of analysis; (4) Classroom discourse. We video recorded all of the lessons and focused on the classroom discussion of discourse understanding and reflection in this paper.

Data analysis and results

Characterizing students' understanding of discourse and change

Students' responses were analyzed to characterize their epistemic understanding of discourse aligned with KB perspective. As Table 1 shows, students' understanding of discourse move towards to more sophisticated views in the enriched KB group in the posttest, such as "putting ideas together to make our knowledge rise-above…" and "to continued build-on…" For the comparison group, even though students' discourse understanding also appeared to have developed in the posttest, such as "…argumentation…obtain an agreement…", they still did not engage in a sophisticated view of discourse understanding while students' discourse understanding in the enriched KB group corresponding more to the KB principles, which are the key themes of KB theory.

Students' responses were coded using a 3-point scheme ranged from simple to more sophisticated views of discourse. A second rater independently coded 30% of the data, with Cohen's Kappa calculated, K=.873, $p<.001$, indicating a good inter-rater reliability. Significant change was obtained from pretest to posttest for the enriched KB group, $t(30) = 4.224$, $p<.001$. The significance of which is corroborated by baseline analysis suggesting no significant difference for pretests between the two groups while an independent sample t-test indicated significant difference for the posttests between the two groups, $t(61) = 2.063$, $p<.05$.

Table 1: Students' responses about their understanding of discourse

Enriched KB Group		Comparison Group
Pretest	Posttest	Posttest
CYR: "A good discourse need to have a fruitful discussion with everyone participate in".	CYR: "… everyone *express their ideas*, then *putting our ideas together* to *make our knowledge rise-above*…"	GWF: "A good discourse…have *argumentation* and…*obtain an agreement*."
FRM: "a good discourse is collaboratively working…"	FRM: "… we need to have *diverse ideas*…from different perspectives…"	GBY: "…focus on the conceptual topic…identify the *dis/advantages*…"
LQW: "a good discourse need to … develop a harmonious discussion environment".	LQW: "… *continued build-on and questions asking* for sustained inquiry, which help us to *improve our ideas*…"	LTY: "for good discourse…have *group discussion* first, then *summarize our ideas* to present in the community"

How did students engage in KB discourse and sustain the discussion?

Students' online engagement and discourse network

The second research question examined how students contributed to and engaged in online discussion and how they sustained their inquiry through the discussion in KF. We conducted KBDeX analysis to explore how the discourse networks of students' KF notes changed over time between the enriched KB and comparison group. Students' KF notes were exported into KBDeX and it produced a network analysis of students, discourse, and keywords. In this paper, we examined the discourse network only. As Figure 3 shows, the discourse network changed from segmented to coherent over time in the two groups. However, in each phase (phase 1 – notes 1 to 30 and phase 2 – notes 1 to 100), the discourse network was more connected with fewer fragmented notes indicating a more cohesive discussion in the enriched KB group. In phase 1, only two separate notes (highlighted in red) remained outside the main cluster in the enriched KB group, while for the comparison group, the discourse network was segmented, with many separated notes. In phase 2, the discourse network was still segmented in the comparison group with eight fragmented notes, while for the enriched KB group, the discourse network was integrated in one cluster without any fragmented notes. This suggests that over the discussion, students in the enriched KB group engaged in a more cohesive and progressive discussion than in the comparison group.
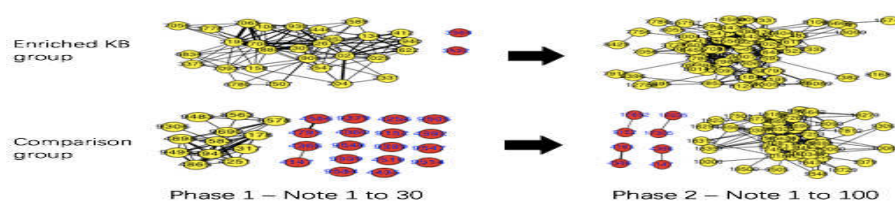

Figure 3. KF Discourse Network Change over time between enriched KB and comparison group.

Inquiry thread analysis of online productive discourse

Students' notes in KF were analyzed to examine their productive discourse engagement. All KF notes were classified into 10 threads (thread 1-art and life; 2-artist; 3-re-creation; 4-purpose of art; 5-definition of art; 6-arts representation; 7-plagiarism of art; 8-difficulties solving by art; 9-how to read art; and 10-arts appreciation) adapted from the notion of inquiry thread with students addressing a conceptual problem (Zhang et al., 2009).

Table 2: 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 visual elements?
	Explanation-seeking	Questions on seeking open-ended responses with explanation	How can we use visual elements to appreciate an art piece?
	Sustained inquiry	Asking further questions based on previous notes or ideas and make the discussion deeper	Art is innovative…but how can art represent emotion? (a further question asked based on previous notes)
Theorizing and Improvable Ideas	Simple claim	Simple (dis)agree or repeat a statement	Art can be free designed (repeat previous note)
	Proposing an explanation	Proposing a theory that explain certain phenomena for the first time	Art include various elements and combines different color and shape
	Supporting an explanation	Supporting an already existing theory proposed by another student and providing a justification	Different color can represent different meaning and give people different feeling, blue represents melancholy…
	Improving an explanation	Improving an already existing theory through elaboration, specifying details and using new evidence	You mentioned that people think that art is useless, but art is an indispensable element in our life…the clothing were designed by art…
Meta-discourse	Connection	Reference to their own or others' notes, or quoting extra sources to advance understanding	▨"arts not equal to pictures", arts represent many forms… photographing…(reference to a student's note and quote extra sources)
	Rise-above	Students refer back to previous discussion by asking a metacognitive question for monitoring the inquiry process and further discussion, or generating an explanation or evaluation	Everyone are artists? You said that ▨ "artists? A special existence", artists refers to people who design projects…, I am wondering that everyone can be artists as long as they drawing or designing projects…Are we artists?

Within each inquiry thread, individual notes were coded. The coding framework includes three main categories of questioning, theorizing, and meta-discourse, all of which correspond with sub-codes. The development of the coding scheme (Table 2) was based on a theory- and data-driven approach, in which several theoretical frameworks were integrated including questioning and explanation (Hakkarainen, 2003), ways of contributing (Chuy et al., 2011), and the social dynamics of KB (Yang et al., 2016). A second rater coded 30% of data, K=.830, $p<.001$, indicating a good inter-rater reliability. As Table 3 shows, the results from our analysis suggested that students' questions were primarily explanation-seeking, moreover, asking sustained questions for further inquiry; in addition, students focused on generating a theory and providing a detailed explanation to support the theory. Overall, results showed that students were engaged in productive discourse with high-level responsibility taken for knowledge building.

Table 3: Number of different categories of epistemic questioning, theorizing, and community in inquiry threads

Thread	Questioning and Identify Gaps			Theorizing and Improvable Ideas				Meta-discourse	
	Fact-seeking	Explanation-seeking	Sustain inquiry	Simple claim	Proposing	Supporting	Improving	Connection	Rise-above
#1	0	1	1	1	3	2	2	0	1
#2	1	2	2	0	7	1	0	2	1
#3	1	4	1	5	5	3	0	1	1
#4	1	1	1	1	3	1	0	0	0
#5	2	8	6	10	18	2	1	2	3
#6	0	2	6	4	9	6	0	0	0
#7	0	2	3	1	10	1	0	0	1
#8	0	0	5	4	9	3	2	0	4
#9	0	3	1	0	7	2	3	1	5
#10	0	20	1	3	17	3	0	1	0
Total	5	43	27	29	88	24	8	7	16
Mean	0.5	4.3	2.7	2.9	8.8	2.4	0.8	0.7	1.6
SD	0.71	5.95	2.16	3.07	5.18	1.51	1.14	0.82	1.78

To understand how students' productive discourse changes, we divided KF notes into two periods (before and after the intervention on discourse understanding and reflection). In the comparative analysis, we analyzed the frequency of high-level discourse moves (Table 4), which suggested that patterns in students' KF discourse changed to a more explanation-oriented inquiry and discourse over time.

Table 4: Frequency of notes within each inquiry thread in period 1 and period 2

	Period 1 (week 1 to 7)	Period 2 (week 8 to 16)
Explanation-seeking question	19	24
Sustained inquiry	11	16
Proposing a theory	45	43
Supporting a theory	6	18
Improving a theory	0	8
Connection	3	4
Rise-above	4	12

In addition to analyzing the notes within each thread, Figure 4 provides a holistic picture of students' thread discussion development. In Figure 4, the numbers in parentheses represents the number of notes created and the number of authors in each thread, respectively. Dotted lines across threads represent notes that were included in more than one inquiry thread indicating that one idea was discussed among different conceptual topics. As Figure 4 shows, even among low-achieving students, discussion was able to be sustained over a length period of time on key conceptual issues. These threads also lasted from the beginning of the semester to the end, suggesting that students were more engaged in these topics and even inquired further by asking sustained questions, proposing and improving explanations.

Additional quantitative analyses indicated that these productive discourse moves correlated with students' epistemic understanding of discourse. For questioning ($r=.556$, $p<.01$), theorizing ($r=.471$, $p<.01$), and a reasonable correlation in metadiscourse ($r=.349$, $p=.054$). The findings suggested that students with deeper understanding of discourse were more likely to be engaged in productive discourse.
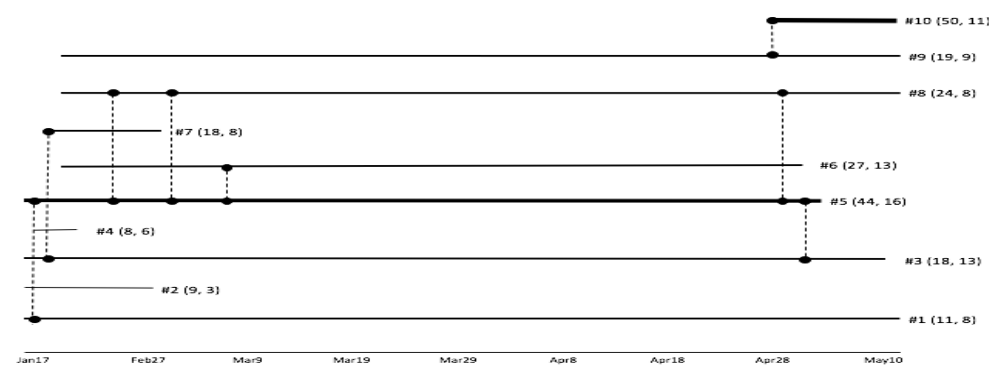
Figure 4. Network of inquiry threads in KF.

Meta-Talk about KF discourse and knowledge building principles

The third research question examined how low-achieving students were engaged in productive classroom discourse in developing their knowledge building work. Three themes were identified.

For low-achieving students, one of the scaffold is to have them engage in drawing and visualizing their work. Figure 5 shows the drawings that students made to illustrate their understanding of discourse and engaged in explicit reflection to compare KF discourse across two classrooms. Low-achieving students reflect on their own discourse albeit by more with limited ways of drawing and language, followed by classroom meta-talk.
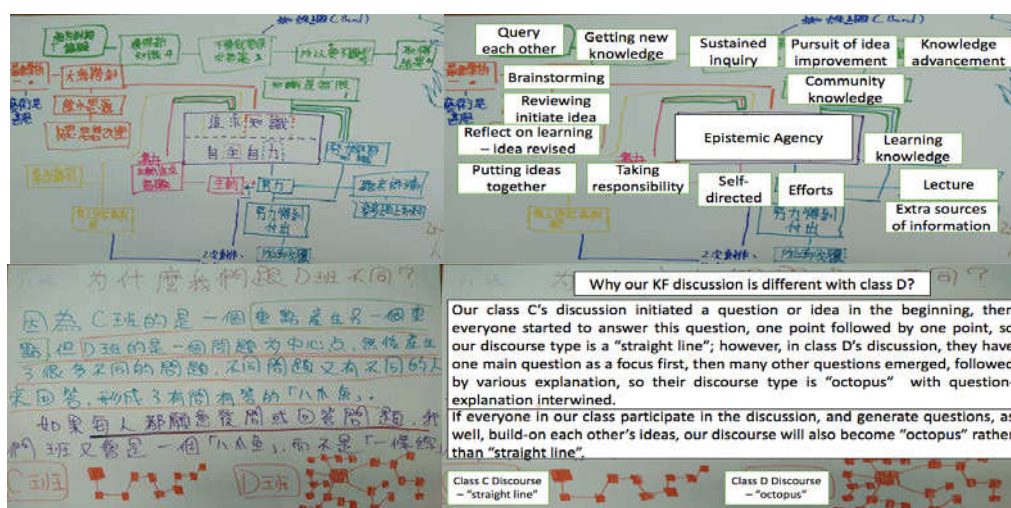

Figure 5. Examples of students' discourse understanding and KF discourse structures compsrison mind map.

Theme 1: Explicit reflection and discussion on discourse comparison

In the following excerpt, the students explained the difference between their own and another class KF notes structures. The teacher (T) asked students to identify and explain the notes structures difference. Student 1 (S1) then proposed that the reason for their "straight line" was due to the focus on a single question, S2 made a supplementary point that their ideas are explained directly, then S1 synthesizing the ideas by reflecting on their KF discussion. This excerpt shows how the teacher scaffold students' meta-discourse, to engage deeper thinking about their discourse shapes and why their discourse moves were stopped by comparing with another better discourse moves.

T	Based on our discussion, ***what do you think a good discourse type should look like?*** Can anyone explain the differences of the KF structures?
S1	We ***only focused on one question***, and we did not think and discuss from different perspectives.
S2	***Our ideas followed by another ideas directly***.
	…

T	So our class KF discussion stop at this point, meaning we cannot move to a new stage. The "octopus-shape", can you explain the reasons for this by reflecting on your KF discussion?
S1	In the beginning, our *initial idea* had four build-on notes, but later, our build-on notes become *a line and one followed by one directly*. However, the other class, they had two build-on notes for the initial note, and later, they had another two build-on notes in response to the above different notes, and *continue to rise-above for inquiry*, then, a new question was emerged. In our case, we only have one question, all the build-on notes respond to this question directly, and *we did not inquiry further*.

Theme 2: Reviewing and reflecting on the state of knowledge and understanding

The teacher started to help students engaged in meta-talk by reflecting on what they had learned, the teacher initiated a question on "can you reflect on what you learned from these KB lessons?"

T (Teacher)	*Can you reflect on what you learned* from these KB lessons?
S1	*What I had learned* is *how to set goals,* and how to think about a problem towards setting goals.
T	Any more ideas or build-on?
S2	I think we needed to have *diverse ideas*, means that we need to think about a problem from various perspectives.
S3	*We discussed the knowledge building principle* of collective responsibility, as we are doing now, *we listen to others' ideas, then work collaboratively and discuss together for further problem solving*.
T	Any ideas?
S1	What we had learned is…how to build ideas and knowledge. We are learning a thinking model that is *taking collective responsibility* advance community knowledge…we also learned that *we need to put our ideas together, to rise-above further through continued idea improvement*.

As shown in this excerpt, the students tried to review what they had learned. This meta-talk showed reflection on the state of their knowledge and understanding and how students reflect on their epistemic goals and collectively building on each other's ideas for discourse understanding. Students were able to illuminate their understanding of KB principles and their emphasis on being able to "…listen to others' ideas…discuss together for further problem solving…" and "put our ideas together…continued idea improvement".

Theme 3: Identifying deeper focus and core problems

In another excerpt, discussion demonstrates how low-achieving students were able to gradually develop understanding of KB concepts and principles, as they apply discourse insights to their own work in visual arts.

T	*Can anyone explain how can we use this learning model we discussed in visual arts learning*?
S8	We can find materials…take a note, *as what we did in knowledge building*. We can *write down our questions, then our classmates can read our ideas*…which can help us to *generate new questions for further inquiry*.
S9	… when you have an idea, you will *generate new problems or ideas based on the initial one*…
	…
S1	In the first lesson, we discussed that visual art is a representation of creativity…*Similar to KB*, we can learn and develop from others' ideas from different directions. When you get ideas from others, your art works will become diversified. So *art is an integration ideas...the similar of KB.*

In the above excerpt, students started to bridge the KB and their visual arts learning. For example, student 8 responded the application of what they did in KB to arts learning, "…find materials…taking notes", followed by student 9 emphasized on generated new problems based on the initial one. Through the discussion,

student 1 tried to apply KB into arts learning by proposing an idea about the connections between KB and creativity learning and explain the similarities between them.

Conclusions and Implications

The study examined productive discourse developing including both online and classroom discourse to support low-achieving students in their KB work and understanding of discourse. We characterized students' epistemic understanding of discourse aligned with productive discourse engagement. Analysis of discourse on the KF using KBDeX indicated how discourse began to cohere and change over time. Through the KB lessons, students began to engage in discourse in productive ways, including attempts to use meta-discourse to regulate, monitor and advance their knowledge inquiry. There was also sustained inquiry over time. Classroom discourse suggests how low-achieving students can be engaged in meta-talk about their KF discourse supported by explicit reflection. Excerpts from classroom discussions also showed how students were able to talk about KB principles in relation to their own KB work. There have been many studies on pedagogical approaches based on the principles of KB, however, this study showed how students reflect on and talk about KB principles explicitly integrate with understanding of discourse. In sum, this study is particularly important as very little research has focused on how low-achieving students engage in KB work and meta-talk on discourse itself with KB principles.

References

Azevedo, R., Cromley, J.G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology, 29*, 344-370.

Chan, C.K.K. (2011). Bridging research and practice: Implementing and sustaining knowledge building in Hong Kong classrooms. *International Journal of Computer-Supported Collaborative Learning, 6*(2),147-186.

Chen, G., Clarke, S.N., & Resnick, L.B. (2014). An analytic tool for supporting teachers' reflection on classroom talk. In *Learning and becoming in practice: The International Conference of the Learning Sciences* (Vol.1, pp.583-590).

Hakkarainen, K. (2003). *Emergence of progressive-inquiry culture in computer-supported collaborative learning. Learning Environments Research, 6*(2), 199-220.

Hennessy, S., Drummond, S.R., Higham, R., Marquez, A.M., Maine, F., Rios, R.M., Carrion, R.G., Torreblanca, O., & Barrera, M.I. (2016). Developing a coding scheme for analyzing classroom dialogue across educational contexts. *Learning, Culture and Social Interaction, 9*, 16-44.

McNeill, K.L., & Pimentel, D.S. (2010). Scientific discourse in three urban classrooms: The role of the teacher in engaging high school students in argumentation. *Science Education, 94*(2), 203-229.

Oshima, J., Oshima, R., & Matsuzawa, Y. (2012). Knowledge Building Discourse Explorer: a social network analysis application for knowledge building discourse. *Educational Technology Research and Development, 60*(5), 903-921.

Pluta, W.J., Chinn, C.A., & Duncan, R.G. (2011). Learners' epistemic criteria for good scientific models. *Journal of Research in Science Teaching, 48*(5), 486-511.

Sandoval, W.A. (2003). Conceptual and epistemic aspects of students' scientific explanations. *Journal of the Learning Sciences, 12*(1), 5-51.

Sandoval, W.A., Reiser, B.J. (2004). Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education, 88*(3), 345-372.

Sawyer, R.K. (2014). *The Cambridge handbook of the learning sciences*. NY, NY: Cambridge Univ. Press.

Scardamalia, M., & Bereiter, C. (2014). Knowledge building and knowledge creation: Theory, pedagogy, and technology. In R. K. Sawyer (Eds.), *The Cambridge handbook of the learning sciences* (2nd ed., pp.397-417). New York, NY: Cambridge University Press.

van Aalst, J. (2009). Distinguishing knowledge sharing, construction, and creation discourses. *International Journal of Computer-Supported Collaborative Learning, 4*(3), 259-288.

Yang, Y., van Aalst, J., Chan, C.K.K., & Tian, W. (2016). Reflective assessment in knowledge building by students with low academic achievement. *International Journal of Computer-Supported Collaborative Learning, 11*(3), 281-311.

Zhang, J., & Chen, M-H. (2013). Foster sustained, collaborative knowledge building with Idea Thread Mapper. Paper presented at AERA2013, San Francisco, CA.

Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (2009). Socio-cognitive dynamics of knowledge building in the work of 9- and 10-year-olds. *Educational Technology Research and Development, 55*, 117-145.

Zohar, A., Degani, A., Vakknin, E. (2001). Teachers' belief about low-achieving students and higher order thinking. *Teaching and Teacher Education, 17*, 469-485.