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### **Abstract**

Developing productive dialogue for creative knowledge work supported by digital technology is an important education goal in the knowledge era. This chapter examines the nature and development of productive dialogue using the theoretical perspective of Knowledge Building (KB) supported by Knowledge Forum®. The Knowledge Building model, developed by Scardamalia and Bereiter since the 1990s, examines how students engage in progressive dialogue, to pursue sustained collective inquiry, adding value to the class community, similar to the dialogic practice in scientific communities.

This chapter examines *theory, technology, analysis, and pedagogy* related to promoting progressive dialogue, situating the Knowledge-Building model with other dialogical approaches. We first discuss why progressive dialogue is needed in the knowledge era and outline its characteristics, based on the theoretical underpinning of the KB model. We then discuss how Knowledge Forum affordances support advanced dialogic practice, highlighting the need to align technology with principles and pedagogy. We also present analyses of KB progressive dialogue, identifying productive online dialogic patterns and moves. Dialogic pedagogy in KB classroom and design principles for progressive dialogue are examined. Finally, research directions for examining dialogic approaches using the knowledge-building perspective for emerging methods and pedagogy are discussed.

## **Progressive Dialogue in Computer-Supported Collaborative Knowledge Building**

### **Introduction**

The importance of educational dialogue in promoting learning, thinking and understanding is recognized widely (Alexander, 2017; Howe & Abedin, 2013; Mercer & Littleton, 2007; Wegerif, 2013). Recently, there have been major developments examining the mediating role of digital technology in dialogic processes (Major, Warwick, Rasmussen, Ludvigsen, & Cook, 2018), for example, the use of interactive whiteboards (Hennessy, 2011), table tops (Falloon & Khoo, 2014; Haßler, Major & Hennessy, 2016b), microblogging (Cook et al., 2019), and wiki-supported tools for knowledge construction (Pifarré, & Staarman, 2011). Research has shown how meaning is generated through dialogue and how technology can create and open up a ‘dialogic space’ (Wegerif, 2007) for inter-thinking (Littleton & Mercer, 2013). New technology not only makes it possible for dialogue to transcend time and space, but also provides opportunities for dialogue to be dynamic, creative, and transforming.

A major research area, computer-supported collaborative learning (CSCL), provides a rich paradigm for examining technology-supported dialogue. Stahl, Cress, Ludvigsen and Law (2014) discussed how dialogicality provides a new theoretical lens for conceptualizing collaboration; reciprocally, CSCL technology contexts enable new forms of dialogue to emerge and raises new questions (see Major & Warwick, this volume). CSCL researchers have postulated different theories and metaphors of learning (Paavola & Hakkarainen, 2005), including knowledge acquisition, social acculturation, and knowledge creation, the latter examining the creation of knowledge within and across communities (see Ligorio, Amenduni & McLay, this volume). This chapter aims to examine dialogue for creative knowledge work extending from groups to communities.

This chapter examines Knowledge Building (KB) (Scardamalia & Bereiter, 2003; 2006; 2014), that has been considered one of the exemplary dialogic approaches in CSCL research (Wegerif, 2007, p.310). The KB model, also known as knowledge creation (Bereiter & Scardamalia, 2014) , involves participants’ collective efforts and *progressive dialogue* in adding value to and extending the knowledge frontiers of their community. In KB classrooms,

students collectively generate problems, co-construct explanations, revise their theories, and pursue sustained inquiry through online and offline discourse. Aligned with how technology enables the shift from teacher- to student-directed learning (Major & Warwick; Staarman & Ametller, this volume), KB highlights students' contributions to community advancement. KB progressive dialogue involves students' collective epistemic agency and progressive inquiry (Hakkarainen, 2003; Scardamalia & Bereiter, 2006) -- When one problem has been solved via dialogue, students collectively invest their efforts to solve emergent new problems progressively in ways similar to scientific dialogue in scientific communities. Progressive dialogue is central to the KB model, and supported by Knowledge Forum® (KF).

Although KB is primarily a dialogic model, few research efforts have examined dialogic education from a KB perspective. This chapter aims to situate KB with other dialogic approaches, examining how progressive dialogue can be conceptualized, assessed and developed in technology-supported classrooms. We first discuss the centrality and nature of progressive dialogue in the knowledge age using the theoretical lens of KB. Second, we discuss KF affordances for supporting progressive dialogue. Third, we examine how progressive online dialogue can be analysed, and the roles of dialogue moves in conceptual learning. Fourth, we discuss dialogic pedagogy in KB classrooms, highlighting key design principles. Finally, future research directions for examining dialogic approaches using the KB lens are discussed. Most KB literature uses the term 'discourse' to emphasize written discourse on KF; however, as KB involves different forms of dialogue beyond written texts, the term 'dialogic moves' has also been employed (Bereiter and Scardamalia, 2016). In this chapter, discourse and dialogue are used synonymously.

### **Theoretical Underpinning of Knowledge Building as a Dialogic Approach**

Dialogic literacy is a fundamental goal for educated citizenry in our globalized world and knowledge-based society (Bereiter & Scardamalia, 2005). In the knowledge era, students need to develop productive dialogue to inquire, to innovate, and to engage in creative knowledge work (Bereiter & Scardamalia, 2005). KB examines how people work together to advance the state of community knowledge (Scardamalia & Bereiter, 2006; 2014); the goal of progressive KB dialogue is to generate and improve existing community knowledge. To support progressive

dialogue, Scardamalia and Bereiter developed the Computer-supported Intentional Learning Environment (CSILE), one of the first CSCL platforms, in the late 1980s, followed by Knowledge Forum (KF) in 1997, which has undergone continual development since then. Research in the last three decades has shown how students can engage in productive discourse in KB with demonstrated evidence of students' conceptual learning and knowledge advance (see review, Chan, 2013; Chen & Hong, 2016).

There are many different meanings of 'dialogic,' and research on productive dialogue has different emphases (Wegerif, 2011). A major research area in dialogic education has examined classroom dialogues — the promotion of dialogues as chains of questions, and the exploration of ideas through teacher-student dialogues (Alexander, 2017; Mercer, 1995; Resnick, Asterhan & Clarke, 2015); the characterization of classroom dialogue is a major theme (Howe & Abedin, 2013). Alexander (2017, 2018) postulated "dialogic teaching," for harnessing the power of talk to stimulate student thinking involving teacher-student co-construction and negotiation of knowledge. Michaels, O'Connor and Resnick (2008) discussed "accountable talk," emphasizing different dialogic practices and students' community accountability. Mercer (1995; 2008) identified three distinctive kinds of classroom talk, including disputational, cumulative, and exploratory talk. Productive classroom dialogue, also called exploratory talk, involves students' joint reasoning and engaging constructively with each other's ideas for knowledge construction (Mercer & Littleton, 2007).

The role of dialogue in influencing thinking, learning to learn and creativity is another major research theme (Wegerif, 2011; 2015). Using a Bakhtinian perspective, Wegerif (2007) argued that learning to think involves engaging students in dialogic processes, drawing together multiple perspectives and seeing others' viewpoints; this meeting of different and conflictual perspectives brings about emergent understanding. Researchers have examined how technology plays a central role that enables dialogue to be externalized for reflection, opening, deepening, and broadening the dialogic spaces (Major et al., 2018; Wegerif, 2007). Wegerif (2007) argued that dialogue is key — not just as a means for constructing knowledge, but an *end in itself*. Similarly, Mercer and Littleton (2007) postulated that students not only learn *through* dialogue, but also *for* dialogue.

The KB model resembles current dialogic approaches — for example, principles of collective work, reciprocity, support, building-on and accountability to one's community

(Michaels et al., 2008) are advocated through KB's focus on collective responsibility. KB addresses similar issues as do dialogic researchers — Bereiter (2005) discussed the “mind as container” problem in education. Like the notions that dialogue is never closed and that what constitutes knowledge is never final (Wegerif, 2011), KB progressive dialogue can be characterized as dialogue that generates more dialogue, knowledge that creates more knowledge (Bereiter & Scardamalia, 2014). Primarily, KB seeks to extend dialogue from knowledge construction to dialogue for creative knowledge work in scientific communities.

Drawing from historical development, Bereiter and Scardamalia (2005) argued that dialogue underpins all knowledge disciplines and is pivotal in contributing to the development of scientific and systematic knowledge in our cultural heritage. In a similar vein, dialogue is important in innovative and progressive organizations in the knowledge-based era — new knowledge and new directions are also forged through dialogue. Bereiter and Scardamalia argued that such dialogue typically goes beyond reasoning, debates, and persuasion (general rhetoric) to include explanatory coherence and progressive problem solving for the generation of new ideas. Productive dialogue, using the KB perspective, has an epistemic focus highlighting community dynamics - emphasis is placed on the collective progress of dialogue for idea improvement and knowledge generation.

The key argument is that, for creative knowledge work, students in the knowledge era need to be provided opportunities to engage in dialogue *similar to* that found in knowledge disciplines and innovative communities. Supported by design and technology, school-aged students can work in similar ways as scientists and innovators, pushing the frontiers of knowledge of their community through progressive discourse (see review, Chen & Hong, 2016). Like scientific progress, KB progressive dialogue is ever-deepening, involving collective epistemic work to turn fragmented explanations into coherent theories for creative knowledge work. KB dialogue aligns with multiple perspectives but it also involves students' collective agency combining diverse perspectives into higher-level, coherent perspectives.

Two key epistemic dimensions of KB theory characterize KB progressive dialogue. The first is the distinction between learning for individual growth and KB for the development of public knowledge (Scardamalia & Bereiter, 2006, 2014). Bereiter incorporated the World Three idea from Popper's theory of objective (public) knowledge; students not only learn existing curriculum knowledge, they are also engaged in the process of improving and generating new

knowledge for their community. Similar to dialogic theory, which emphasizes dialogue with infinite others in the cultural heritage (Wegerif, 2011), KB dialogue aims to advance the frontiers of public-collective knowledge of the community, much as scientists historically do. Although school-aged children cannot create new knowledge unknown to human kind, they *can* engage in the *process* of knowledge creation used by scientists via progressive dialogue. For example, Scardamalia and Bereiter (2006) referred to a student's KF online post ("Mendel worked on Karen's problem") to show how these children viewed that they were not just learning curriculum knowledge about genetics; Karen and others had joined ranks with Mendel to create public knowledge for their peers, and pushing the frontiers of public knowledge of their communities.

The second epistemic dimension is the distinction between 'belief-mode' and 'design mode' dialogue, both important in different ways. Belief-mode dialogue is concerned with how students make claims, justify their beliefs, and reason to support their arguments, as reflected in such questions in classroom dialogue as "Can you elaborate what you mean?", "What are your reasons?" and "Can you provide evidence?" KB adds another dimension — design-mode dialogue — that involves theory-building and helping students to see ideas as conceptual artefacts for improvement (Bereiter & Scardamalia, 2003). Design-mode dialogue may include questions such as "What can be a better explanation and how would you revise your ideas?", "How do you synthesize these different ideas to improve the explanation?" and "What have we accomplished together and what new problems/questions have emerged? Design-mode dialogue, like scientific dialogue, aims at bootstrapping to higher-level knowledge. Each episode opens new problems/possibilities; when a problem is solved, efforts are reinvested to tackle deeper problems. While both modes of dialogue are important, design-mode dialogue has been examined less in classroom talk and with emerging technology, these new forms of dialogues for knowledge generation need to be examined.

While the term knowledge advance in KB is often used, the focus is not on knowledge content as the end-state— KB is synonymous with the continued pursuit of inquiry and evolution of dialogue. Progressive KB dialogue features several key epistemic commitments: (a) seeking collective progress beyond sharing, building-on and evaluating ideas; (b) developing rise-above beyond compromised and common understanding; and, (c) formulating meta-dialogue that tracks community progress for sustained growth. KB progressive dialogue is purposeful, but has no

fixed goal and is ever-deepening; its goals evolve as the dialogue proceeds. The ability to sustain deepening, purposeful dialogue is important for dialogic literacy in the knowledge age.

The KB model is well aligned with dialogic theory emphasizing students taking up multiple perspectives (Wegerif, 2011) – the KB emphasis on a *community context* and *public knowledge* can help further to maximize bringing together these multiple perspectives and diverse models. In alignment with the meeting of minds/perspectives for new ideas, the KB principles of *collective epistemic agency* and *design mode* advocate students taking responsibility for *idea improvement* that can propel the emergence of new ideas and ever-deepening dialogue. While the notion of ‘collective’ has been emphasized in dialogic and CSCL research (e.g., group cognition, Stahl, 2006), the KB model focuses more explicitly on collective *progress* as in knowledge creation in scientific dialogue. Productive dialogue can be enhanced in a community context with the continued pursuit of collective idea improvement supported by technology.

### **Technological Affordances of Knowledge Forum for Progressive Dialogue**

Digital technology plays a pivotal role with different affordances in supporting productive online/classroom dialogue (Major & Warwick, this volume). Knowledge Forum (KF) is central and it has been evolving with the KB model over the past two decades. Its digital technologies are designed to support progressive dialogue for creative knowledge work. We first introduce the key features of KF (Figure 1) and the general technology affordances for productive dialogue (Hennessy, 2011). We then illustrate specific KF technology affordances linked to KB principles and KB dialogic pedagogy.

### **Features of Knowledge Forum and Affordances for Productive Dialogue**

*KF View.* The basic unit in KF is a “View”: a collaborative dialogic workspace where students contribute their questions and ideas and build on others’ ideas (Figure 1, top). Students can contribute “Notes” to different Views that reflect the community’s core ideas and progress. Views make ideas public, allowing students to refine ideas and reformulate problems in a community dialogue. The View background is designed not as a bulletin board, but as a graphic space that can be co-designed by teacher and students as the dialogue proceeds. The grouping of KF Notes also opens up dialogic space for developing emergent and higher-level conceptualization of knowledge.



Figure 1. Features of Knowledge Forum supporting progressive dialogue.

Note: (1) View (top) The collaborative workspace where students contribute and build-on these notes for dialogic inquiry; (2) A KF Note (bottom left) with scaffolds, keywords and reference notes for theory-building dialogue; (3) and Embedded Assessment Tools (bottom right) for concurrent feedback on KF activity and dialogue.

*Notes and Scaffolds.* A Note and networks of Notes (red icons, Figure 1, top) are idea objects and build-on structures displayed in the View. Students can write or co-author Notes, which can include questions, statements, build-ons, evidence, plans, and graphics. When writing a KF Note, students can use “Scaffolds” — metacognitive prompts that support their dialogic inquiry (e.g., “I need to understand,” “My theory,” “New information”, “A better theory”, “Putting our ideas together,” etc.) (Fig. 1, bottom left). Teachers/students can add or modify scaffolds for different curriculum contexts. KF Notes can be edited, revised, and annotated for idea improvement. Keywords can be added to facilitate searches and to focus on key domain words in enriching the dialogue.

*Linking and Rise-Above.* KF features include support for linking and rise-above for KB progressive dialogue. The networked build-on Note structure, unlike the downward sequence common in online forums, facilitates the multiple linking of notes to views and sub-views (Fig 1, top) and moving notes around to allow ideas/questions to be posed in different Views (contexts).



Rise-above processes, using “Reference Notes”, enable students to cite others’ ideas, with hyperlinks to the original Notes (Fig. 1, bottom left), similar to what scholars do in disciplinary inquiry. Students can also use “rise-above Notes” and “rise-above Views” (a View of Views) to synthesize a cluster of notes, or combine promising ideas into another higher-level view, thus helping students work towards synthesizing higher-level knowledge and deepening dialogue.

*Assessment and Analytic Tools.* Accompanying KF is a set of assessment and learning analytics tools that record students’ online activities and dialogues such as note contributions, interactivity (social network analysis), use of scaffolds, and lexical analysis for vocabulary growth (Fig. 1, bottom right). Knowledge builders monitor their work and engage in self/collective assessment of their progress in their dialogue. Different new analytics tools (e.g., Knowledge Building Discourse Explorer (KBDeX), Oshima, Oshima, & Matsuzawa, 2012) can capture temporal dimensions of students’ dialogue on KF. Presenting analytic evidence of their KF online writing and dialogue can help students to engage in reflective dialogue (e.g., Are we building onto others and what next?), thus helping them deepen their dialogue.

Different kinds of affordances have been identified using CSCL tools to enhance dialogue (Hennessy, 2011; Major et al, 2018). Similarly, KF technology provides technology-enhanced affordances, including: (a) Visibility—Views are open collaborative spaces wherein students’ ideas are foreground, juxtaposed, connected and compared, and provide visualization of on-going dialogue and community progress; (b) Provisionality—students can revise KF Notes any time, thus supporting the progressive nature of dialogue; (c) Interactivity—Notes can be moved via KF’s flexible-build-on structure, a non-linear mode that enriches interactivity, allowing students to link and develop ideas into more coherent lines of thinking and discourse; (d) Multi-modality – KF includes different modalities (i.e., text, graphics, video), allowing multiple diverse interpretations to open richer dialogue; (e) Trajectory and history—KF’s networks of Notes/ideas, including their posting/revision history, can be tracked via KF’s assessment tools; and, (f) Revisiting and repositioning—KF allows ideas to be modified in different ways, with rise-above Views facilitating the reformulation and emergence of new ideas and multiple perspectives.

### **KF Technology Affordance aligned with KB principles and KB Dialogic Pedagogy**

While technology affordances are important, dialogic intentions and pedagogy play pivotal roles in digital environments (Mercer, Hennessy & Warwick, 2010). To help researchers and teachers work with KB, Scardamalia (2002) postulated 12 KB principles, as indicators of knowledge building. This set of principles also represents the dialogic intentions and goals of the KB community. Table 1 shows how KF affordances for productive dialogue align with KB principles and pedagogy.

Table 1. *KB principles, technology affordances and dialogic pedagogy for progressive dialogue*

Knowledge Building principles	KF Technology Affordances	KB Dialogic Pedagogy
<p><b><i>Real Ideas and Authentic Problems.</i></b> Knowledge problems arise from students’ efforts to understand the world with sustained pursuit into the problems</p>	<p>KF <i>View</i> provides a collective dialogic space for contribution of questions and ideas; <i>build-on note</i> structure supports inquiry into key problems; <i>scaffolds</i> such as “I need to understand” highlight key problems</p>	<p>Students engage in classroom dialogue to generate problems; post problems/questions on KF (e.g. Why do leaves change colour?); tackle deep problems beyond text-book tasks and pursue sustained inquiry</p>
<p><b><i>Improvable Ideas.</i></b> All ideas are viewed as improvable; continual efforts to work on the quality, coherence and utility of ideas</p>	<p>KF <i>Notes</i> can be revised, annotated, and revisited; <i>Scaffolds</i> such as “my theory” and “a better theory” support theory revision; <i>Rise-above Notes/Views</i> support higher-level idea formulation; <i>Assessment tools</i> provide feedback for refinement and idea development</p>	<p>Students build on, revisit and revise ideas for theory building via KF/classroom dialogue; reflect on what has been accomplished and identify promising ideas for deepening dialogue</p>

**Epistemic Agency.** High-level agency negotiating the fit between own and others' ideas, using contrasts to spark change; take charge of high-level work including goal setting, monitoring and evaluation

KF *scaffolds* support theory building and comparison of own, others' and scientific ideas (e.g., INTU, my theory, new information, a better theory); flexible Note and view structures and *linking* support student agency across contexts

Students pursue problems in dialogic inquiry using theory-building scaffolds ---grapple with their own ideas in relation to peers' ideas and scientific models and use differences to chart progress; take agency to generate own problems and work towards these goals

**Idea Diversity.** To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it

KF has different *modalities* (e.g., graphics, video note) that support different representations of ideas and perspectives; *multiple linking* facilitates bringing together of diverse ideas; *analytic tools* show diversity and connectedness of ideas

Students put forth diverse ideas on KF using texts, graphics; videos; seeding of multiple ideas supported by classroom dialogue; students articulate diverse and multiple problem-solving paths

**Rise Above.** Continually working towards higher-level formulation of problems for synthesis and emergent questions

*KF Rise-above Notes and Views* embed multiple ideas for emergent goals and higher-level knowledge; *KF Reference Notes* include hyperlinks to other KF Notes for synthesis

Students write rise-above notes to synthesize diverse ideas and create rise-above views to deepen dialogue; write KB portfolio using *References* function to incorporate (cite) and track other ideas for rise-above and synthesis

**Community knowledge/collective responsibility.** All participants share high-level responsibility to contribute ideas to the community; awareness of state of community knowledge

*KF View* supports and visualizes community progress and state of knowledge; *Note-linking, search and rise-above* support continual refinement of collective dialogue; *analytic tools* help monitor students' contribution to community

Students take collective agency pursuing dialogue; collective idea improvement as a classroom norm; opportunistic and emergent groups (not fixed group); develop community awareness of cutting edge of knowledge

**Constructive Use of Authoritative Sources.** Creative work requires familiarity with current and cutting-edge knowledge of the field; authoritative information examined combined with a critical stance

*KF Scaffold* "New Information" encourages use of source information and the search for evidence to enrich dialogue; different *KF* modalities support bringing in different information; analytic tools test use of domain terms and new information

Students incorporate new information to support their theory-building dialogue; use authoritative sources constructively and critically for theory revision; enrich community dialogue through bringing in diverse sources of information

**KB Discourse.** Discursive practices with explicit goals to advance knowledge beyond sharing information; knowledge is transformed by the discourse process

Flexible *Note-structure* and *multiple-linked* views supports deepening inquiry threads and emergent goals; revision, reference, and rise-above features encourage students to engage in transformative dialogue; analytic tools support viewing of discourse quality

Students engage in KB classroom talk regularly to reflect on *KF* dialogue; meta-talk helps them to develop collective reflection towards deepening their KB discourse

***Embedded, concurrent and Transformative Assessment.***

Continual assessment is central to community progress; assessment is embedded in curriculum with concurrent feedback for transformative learning

*KF assessment and analytic tools*, providing concurrent feedback, support monitoring and improvement of ideas; reference notes and rise-above support assessment of community progress

Students engage in reflective assessment of KF work- write KB portfolios to assess community progress; employ analytic-tools and engage in analytics-supported dialogue using concurrent feedback data to deepen their KF inquiry and dialogue

***Democratizing Knowledge.*** All students are valued contributors to the community; diversity is considered as a strength and all are empowered to engage in knowledge work

*KF co-authored Notes* support students of different abilities to work together; analytic tools, assessing evenness of contributions and other indicators, can be examined for extent of distributed work

Students valuing different ideas and everyone a valuable member; KB classroom culture encourages everyone to contribute; inclusivity emphasized: high and low-achievers work together

***Symmetric Knowledge Advance.*** Knowledge advancements are symmetrical with different parties across teams/communities advancing together

*KF view design* and co-construction of views and databases can be supported within and between teams/ communities; analytics tools demonstrate growth in different communities

Students engage in cross-group/community; KB dialogue inquiring into similar and related problems; virtual classroom visits; shared expertise for advancing knowledge

<p><b><i>Pervasive Knowledge Building.</i></b> Knowledge building not restricted to any specific class; pervades mental life in and out of school context; Knowledge building as a way of thinking and living.</p>	<p><i>The KF database provides a</i> community space that can be expandable to different areas within and outside school contexts that students see relevant; KF database can be used as a resource for future work</p>	<p>Students reflect explicitly on how KB dialogue is applicable outside the specific class to other areas within and beyond school contexts</p>
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While the KB principles overlap somewhat, each has a distinctive focus. Several are critical for productive KB dialogue: (a) collective responsibility and agency; (b) idea improvement; (c) rising-above and emergence; and, (d) reflective/transformational assessment. These principles are dialogic intentions that help students to develop collective dialogic orientations, which are important for opening dialogic space for progressive dialogue. The analysis of technology affordance (Hennessy, 2011), elaborated with the alignment with KB principles and pedagogy, illuminates how KF technology supports progressive dialogue for creative knowledge work. KF's affordances for productive dialogue are enhanced continually through newly-developed assessment tools and analytics in new versions of Knowledge Forum.

### **Analysis of Progressive Dialogue in Knowledge Building**

In knowledge building, KF technology not only provides affordances enabling progressive dialogue, digitally-mediated dialogue on KF also demonstrates collective conceptual artefacts (Hennessy, 2011) and productive knowledge work. This section examines how online KF progressive dialogue is examined, including coding schemes for the characteristics of productive online KB dialogue and evidence of conceptual learning (for evidence, see also Chan, 2013; Chen & Hong, 2016).

Earlier research analysing online KB dialogue has used coding methods to examine progressive inquiry emphasizing theory building. Hakkarainen (2003) postulated “depth of

inquiry” and examined KF discourse in terms of whether young students can pursue problems and build explanations as scientists do. Coding of online KF dialogue as different levels of explanatory discourse moves was related to students’ conceptual progress (Hakkarainen, 2003), evidencing productive moves. Continuing this theme, recent research has identified a set of productive online dialogue moves, including the ‘uptake’ of new ideas, problematizing information, tackling conflict, deepening explanations, and sustained questioning. Analysis has provided evidence showing how different theory-building dialogic moves predict science learning in fifth-grade students (Lin & Chan, 2018).

Analysis of online KB progressive dialogue has continued to be prominent in research on theory-building, and has been examined according to the “Ways of Contribution” scheme (Chuy, Resendes, Tarchi, Chen, Scardamalia & Bereiter, 2011). This coding scheme identifies different categories of dialogic moves, in a cyclical way, including: questioning (formulating an explanatory/design question); theorizing (proposing, supporting, improving and/or seeking an alternative explanation); obtaining information (asking for information, designing experiments to test hypotheses, introducing sources); working with information (providing information to support/discard a theory, weighing/accounting for conflicting explanations; improving design); syntheses and analogies (synthesizing available ideas, creating analogies, initiating rise-above); and supporting discussion (using diagrams to communicate ideas). The scheme has been employed in various studies (Chen et al., 2015; Resendes et al., 2015). demonstrating that even young students can engage in these productive dialogue moves in KB/KF environments with effects on their conceptual knowledge (Chen et al., 2015).

Bereiter and Scardamalia (2016) focused specifically on constructive dialogic moves for knowledge creation that included problem definition, new ideas, promisingness evaluation, comparison, critical discourse, high-level ideas and meta-discourse. These different dialogic moves aim to capture how scientists pursue inquiry and generate knowledge. One of these categories, *meta-dialogue* (dialogue about dialogue) — how students use the rise-above approach to synthesize the community dialogue and identify new problems for continued dialogue — may reflect the KB rise-above dialogic intentions but have been examined relatively less in CSCL schemes. Similar to what scholars do, students can engage in meta-dialogue (meta-review) to bootstrap their dialogue and collective knowledge. There is some initial evidence indicating that

these meta-discourse moves may predict tertiary students' conceptual advances in KB environments (Lei & Chan, 2018)

A seminal dialogic scheme on classroom talk distinguishes between cumulative, disputational and exploratory talk (Mercer, 1995). Some similarities can be found between classroom talk and online discourse. van Aalst (2009) distinguished three modes when analysing KF discourse: (1) knowledge-sharing mode (sharing of information/ideas with limited processing); (2) knowledge-construction mode (co-constructing knowledge through asking explanation questions, interpreting evidence, evaluating hypotheses); and, (3) knowledge building/creation mode (pursuing promising ideas; sustaining questioning; awareness of state of community knowledge; meta-discourse). There are some similarities between cumulative talk with knowledge-sharing discourse with mere sharing of information, and exploratory talk with explanation-oriented knowledge construction/knowledge building discourse. KB mode also emphasizes rise-above and meta-discourse, focusing on students' epistemic commitment to collective progress.

Further work (Fu, van Aalst & Chan, 2016) extends the three-mode scheme identifying nine discourse patterns through analysing KF databases. These patterns are: (1) Knowledge-Sharing mode including (i) fact-oriented, (ii) cumulative, (iii) repetitive, (iv) simple argumentation, and (v) disputational discourse; (2) Knowledge-Construction mode including (vi) explanatory and problem-centered inquiry, and (vii) complex argumentation discourse; and, (3) Knowledge-Building mode including (viii) progressive inquiry and (ix) sustained discourse for community advance discourse. These diverse patterns reveal a range of approaches applicable to other kinds of online dialogue in online discussion. Analyses indicate that students using the more sophisticated modes also develop stronger conceptual knowledge (van Aalst, 2009).

These systems of KB online dialogic moves help to illustrate the characteristics of progressive discourse postulated by KB theories, and to assess whether productive KB dialogue is developing; they can also become goals and criteria for promoting productive dialogue supported by KB dialogic pedagogy.

### **Dialogic Pedagogy for Progressive Dialogue in Knowledge Building**

Designing dialogic pedagogy for promoting creative knowledge work is an important theme for KB and dialogic education (see Pifarré, this volume). Research has indicated the



difficulty of developing exploratory talk (Howe & Abedin, 2013). KB dialogic pedagogy, like other dialogic teaching approaches, emphasizes active student involvement as a collective endeavour (Michaels et al., 2008), extended student contribution for co-construction of knowledge (Mercer, Hennessy, & Warwick, 2010), and the use of ground rules and principles (Dawes, Mercer & Wegerif, 2004). KB dialogic pedagogy is to reflect and enact the theory of progressive dialogue emphasizing collective agency for idea improvement. Different approaches are developed to encourage exploratory and KB talk — the general KB pedagogy is introduced first, followed by a discussion of key pedagogical principles.

In KB classrooms, students engage in creative knowledge work; dialogue is central, and online and offline dialogues are intertwined. Students often start by generating their own problems using face-to-face dialogic inquiry in the classroom, then record and work on their ideas on KF. Classroom inquiry frames their online dialogic work, in turn enriching classroom dialogue. Using different modes of dialogue, students formulate problems, identify promising ideas, co-construct explanations, refine problems, and revise theories progressively, establishing high-level goals to deepen inquiry for theory revision. KB meta-talks and KF assessment/analytics tools are used to scaffold students to reflect on their continuing dialogue (Zhang et al., 2007).

KB dialogic pedagogy is principle-based —teachers focus on a set of principles (Scardamalia, 2002; see Table 1), rather than on a prescribed sequence of tasks, as is common in cooperative/collaborative design (Slavin, 2011). This does not mean that classroom tasks and activities do not exist; rather, the teacher focuses on how principles are enacted varying the tasks to suit the emerging lesson goals and students' epistemic needs. Paralleling the emphasis on collective agency, idea improvement, rise-above, and reflective assessment (Section 3), several pedagogical principles are discussed.

*Collective agency and KB culture for dialogue.* KB includes both online and classroom dialogue. To engage students in exploratory talk, a KB classroom culture of collective agency needs to be developed. Within a broadly-defined curriculum area, students post their ideas/questions openly (e.g., on the KF wall or posters) and they actively generate problems and pursue dialogic inquiry on KF as a community. Following some initial KF/classroom work, a KB talk takes place that usually involves the class sitting in a circle with the teacher, who participates as a group member — listening, building onto ideas, questioning, explaining,

modelling, and sustaining dialogue. Typically, a student introduces a problem/dilemma then ‘hands it off’ to another class member who has indicated an interest in ‘building-on’; and this student-led dialogue continues. These dialogues help students to express what they see as important questions and identify gaps for further dialogue within their community; following the KB talk, they write more on KF, based on their dialogue. The teacher’s role is to demonstrate how s/he also engages in exploratory talk — s/he will ask questions, provide explanations, grapple with the ideas and help to identify the students’ epistemic needs (i.e., wondering why certain questions). Primarily, the dialogue proceeds with collective agency and the teacher acts as a co-investigator alongside the students, as a knowledge-building-community member.

*Idea improvement and idea-centred dialogue.* Dialogic approaches emphasize the interaction of diverse perspectives for the emergence of new ideas (Wegerif, 2011). KB dialogue is idea-driven and dialogic pedagogy includes intentional elements to help students develop an explicit awareness of idea development beyond task completion (Hewitt, 2002) For example, Caswell and Bielaczyc (2002) discussed directly with young students that “ideas” are pretty neat things they can work with, using strategies such as the ‘idea-ball’ metaphor. Students see KF as a place where they can put their ideas for everyone to help improve these ideas collectively. Regularly, students’ KF writing and dialogue is projected on screens and students discuss, during KB talk, how their initial ideas have developed, how they have found some ‘promising ideas’ that need building-on and attention, and how they will revise some ideas further.

*Rise-above and meta-dialogue.* Different dialogic approaches have emphasized the deepening of dialogue (e.g., Accountable Talk, Michaels & O’Connor, 2012). KB pedagogy uses rise-above and meta-dialogue, supported with technology, to deepen and to synthesize their own dialogue. After students have written on KF for some time, there may be various fragmentary ideas; they can use e-portfolios to reflect, track, and synthesize the best work of the community, using reference Notes (van Aalst & Chan, 2007; Lei & Chan, 2018). In classroom KB talks with a meta-dialogue focus, students can engage in dialogue about dialogue; specifically, they can discuss what they have accomplished in pursuing the problem on KF (e.g., “Putting our ideas together,” “We now know...”); identify new questions and emergent goals (e.g., “We still could not understand why...”); design new questions (e.g., “Maybe we can look at this problem in a different way” ), or just reflect on KF progress (e.g., “Is our discussion going anywhere?”). These discourse moves bear some similarities to the modified SEDA scheme including

“coordination” and “reflection on dialogue” (Hennessy et al., 2016; Howe, Hennessy, Mercer, Vrikki, & Wheatley, in press), that merit further investigation.

*Learning-analytics-supported dialogue.* Reflection is important for deepening dialogue. As discussed above, “reflection on dialogue” has been examined in some dialogic coding schemes (Hennessy et al., 2016). With emergent technology, KB dialogic pedagogy involves the use of assessment and learning analytics (see Section 3) to prompt students’ classroom talk about their ongoing KB work. Teachers can work with students to examine what they have done on KF. Using analytics-supported talk, teachers can draw students into deeper dialogues to help them make sense of their work. Concurrent feedback from learning analytics may help widen the dialogic space and provide opportunities for transformative dialogue. Yang et al. (2016) used KF’s Knowledge Connection Analyser to demonstrate how analytic results prompted student classroom and group dialogue on new ideas and questions, supporting students’ metacognition, reflection, and progress for future work.

### **Future Research for Dialogic Approaches and Knowledge Building**

Examining digitally-mediated dialogue from a CSCL KB perspective raises new questions meriting further inquiry. First, as new technologies emerge, dialogue takes different forms, and the integration of online and classroom dialogue becomes an increasingly important area of inquiry. KB examines both KF online and KB classroom dialogue that can provide good opportunities for developing multi-modal and temporal analysis of dialogue, and these methods may be applicable for different dialogic approaches. KB research is developing new assessment and learning analytics technology (Chen & Zhang, 2016; see Section 3), and including the Knowledge Building Discourse Explorer (KBDeX) (Oshima et al., 2012), a social network analysis tool that can be applied to online and offline dialogue simultaneously to demonstrate how ideas develop over time. The turn-by-turn analyses from KBDeX can help reveal temporal dimensions, identifying critical moments of change in dialogue. Ongoing research is taking place using this tool to investigate online and classroom dialogue, tracking possible pivotal points of knowledge building over time (Chan et al., 2019). There are other learning analytics approaches and tools (e.g., epistemic network analysis, Shaffer et al., 2016) that also track the temporal dimensions of dialogue using dynamic network models. The rapid development of

learning analytics has important implications for developing new approaches to the analysis of educational dialogue integrating different modes, and further research is needed.

A second area is continuing the inquiry into the characterization of classroom dialogue (Howe & Abedin, 2013) and incorporating new forms of dialogue moves emerging from the wider use of technology. Knowledge building/creation, as a CSCL approach, has focused on coding schemes for online dialogue, rather than for classroom dialogue moves. Using the insights from dialogic research, research in KB could consider more systematic ways of analysing KB classroom dialogue. On the other hand, current coding schemes, while capturing some important dialogic moves (e.g., reasoning, deepening) have not adequately considered KB aspects of coordination, rise-above, and collective reflection (see discussion above on meta-dialogue and related dialogue moves, Hennessy et al., 2016), and further research would be fruitful. While there may be few instances of these more complex moves in regular classrooms (Howe et al., in press), the incorporation of these dialogue moves has research implications for new coding schemes and pedagogy. As well, researchers have analysed dialogue using different units of analysis, including individual utterances and moves (Hennessy et al., 2016), classroom episodes (Mortimer & Scott, 2003) and those involving episodes, sequences and moves (Wells & Arauz, 2006), many focusing on teacher facilitation. It would also be fruitful to explore coding systems focusing on idea development and rise-above processes, linking across different levels, initiated by both teachers and students at both classroom and group levels.

Third, there are design implications for dialogic pedagogy for the teaching of ground rules and principles. Seminal research in dialogic education has demonstrated the role of ground rules in helping students to think together and promoting exploratory talk (Dawes, Mercer & Wegerif, 2004). As technology changes, new ground rules and norms may emerge for different dialogic goals and processes (see Rasmussen, this volume). KB consists of a set of principles that reflect the dialogic intentions of scientific and collective creativity. Drawing from the insights about teaching ground rules, it would be helpful to investigate how the teaching of KB principles would help students to develop an explicit understanding of what is needed in KB progressive dialogue for community advance. While ground rules for exploratory talk focus on specific principles and strategies (e.g., ask each other questions), KB principles are epistemic principles depicting what KB is about (e.g., improvable ideas) and students need to interpret and reflect upon them. Technology-mediated dialogue may require new ground rules, such as maintaining

joint attention (Rasmussen, this volume) and KB dialogue focusing on collective principles (e.g., rise above). Examining different ground rules/principles with emerging technology and student understanding of what they mean can help reveal students' epistemology of dialogue as a fruitful area of investigation.

### **Summary and Conclusions**

Developing dialogic thinking for collective creativity and innovation is a major education goal in the knowledge era. Dialogue is pivotal in the KB model, which aims to bring the goals and processes of scientific discourse in knowledge communities into education. KB theory highlights collective responsibility and how students engage in progressive dialogue while working with conflictual models for knowledge emergence. In KB, dialogue generates more dialogue and knowledge begets knowledge, similar to the dialogic practices of scientific communities. As with many other dialogic approaches, these new forms of dialogue can be made possible through technology. KF affordances, by linking principles to pedagogy, provide a strong example of how technology can open, widen, and sustain dialogic and reflective spaces for progressive dialogue. KB dialogic pedagogy highlights several principles, including collective epistemic agency, idea improvement, meta-dialogue, and analytics-supported reflection to support exploratory talk for KB. Online and classroom dialogue are intertwined to facilitate progressive dialogue oriented towards creative work in scientific communities.

There may be synergistic advancements examining dialogic education from the knowledge-building perspectives. Dialogic thinking is pivotal in the knowledge age, and KB may help to conceptualize new forms of dialogue emphasizing creative knowledge work. KB theory can be enhanced by using a dialogic lens to focus on diverse models to spark progress, and multi-modal/temporal analysis to examine the trajectory of KB dialogue. The application of assessment and analytics tools in KB can, in turn, enrich the analysis of technology-mediated dialogues. KB classroom dialogue may be illuminated through developing analytic systems similar to those used in dialogic teaching; reciprocally, the emphasis on synthesis, rise-above, and meta-talk may enrich coding systems and research on classroom dialogue. Theoretical, methodological and design implications for dialogic theory and KB model would be enriched through continuing dialogue on these related research traditions.

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