Chapter 2
The Emergence of Rotating Leadership for Idea Improvement in a Grade 1 Knowledge Building Community

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2.1 Introduction

Creative, collaborative engagement with ideas defines Knowledge Building/knowledge creation and is fundamental to work in today's knowledge society: "At its best, the Knowledge Society involves all members of the community in knowledge creation and utilization" (United Nations 2005, p. 141). Collaborative Innovation Networks—in knowledge-creating organizations, research laboratories, and design firms—are advancing the frontiers of the knowledge society (Gloor 2005). Correspondingly, there is growing recognition that schools must shift from preparing students to be consumers to producers of knowledge (e.g., OECD 2015; Tan and Tan 2014). Knowledge Building pedagogy (Scardamalia and Bereiter 2014) represents a longstanding effort aimed at transforming education into a knowledge-creating enterprise by empowering all students to take collective responsibility for creating and advancing knowledge for public good.

Creative work requires flexible, distributed social configurations that support collaborative improvisation and group flow (Sawyer 2015). In Collaborative Innovation Networks (COINs), members have a strong sense of autonomy and self-organize around shared goals, with members rotating leadership as new tasks emerge (Gloor and Cooper 2007). Similarly, in the Knowledge Building classroom, both the teacher and the students share a sense of *collective responsibility* and all members improvise within the context of 12 Knowledge Building principles that support self-organization around idea improvement (Scardamalia 2002). For example, the principles of *idea diversity*, *improvable ideas*, and *rise above* prioritize ideas at the center of class discussions and highlight the iterative nature of idea generation, refinement, and invention in knowledge creation processes that enhance

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the breadth and depth of group understanding and achievement. In a recent study that aimed to assess the Knowledge Building principle of *collective responsibility* (Ma et al. 2016), rotating leadership was uncovered as an emergent phenomenon in three successful Knowledge Building classes, with children as young as 6 and 9 years of age. The current study is exploratory in nature, with the goal of extending this work on rotating leadership by assessing idea improvement and addressing issues surrounding conceptual depth and coherence of student ideas. Two research questions were developed for analysis at the group and individual levels:

1. Over the course of their Knowledge Building, how many students emerge as leaders? What are the pivotal points in the discussion that indicate idea improvement and knowledge advancement?
2. What is a student doing in a leadership position? How does assuming leadership relate to learning outcomes, as reflected in student portfolios?

2.2 Methods

The study took place at the Dr. Eric Jackman Institute of Child Study in Toronto, Canada, where Knowledge Building pedagogy and technology have been implemented and refined over decades of research. The sample consists of 22 students engaged in inquiry about water, while receiving age-appropriate pedagogical and technological supports. Knowledge Forum (Scardamalia 2004) served as the central online space for students to work with ideas and build community knowledge. They contributed their ideas as notes in conceptual spaces called views; developed ideas with "build-on" notes; and synthesized ideas with "rise-above" notes. As Knowledge Forum was integrated into daily classroom practices, students engaged in continuous reading, writing, and revising of notes to advance their community knowledge. Over the course of 3 months, students wrote a total of 198 notes across three views: Water, Evaporation, and Where water goes from our houses. Student-generated problems of understanding included: the water cycle; clouds and weather systems; oceans, lakes, and rivers; sewage and waste management systems; and water as source of life. At the end of their inquiry, a fourth view was created for students to create portfolios and reflect on their understanding of the water cycle.

The student discourse in Knowledge Forum was exported into Knowledge Building Discourse Explorer (KBDeX) (Oshima et al. 2012) in order to perform content-based social network analyses. A list of content-related words (100 words) extracted from the Ontario Curriculum of Science and Technology (2007) was used as "key" ideas in the community knowledge.

KBDeX (Fig. 2.1) is an analytic tool that produces network visualizations of words, notes, and students based on the co-occurrence of keywords in each network: the learners network (top right) shows idea sharing across learners, the notes network (bottom left) shows idea overlap across notes, and the word network

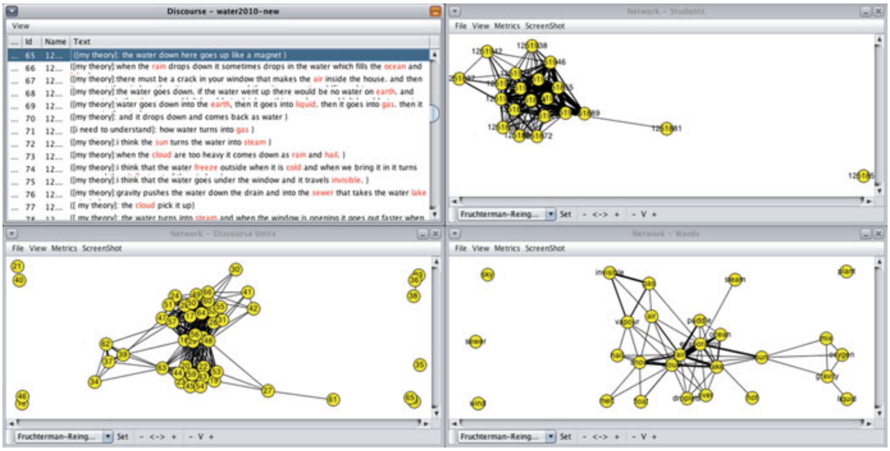

Fig. 2.1 KBDeX visualization of student discourse in Knowledge Forum

(bottom right) shows how ideas are connected in the community knowledge as group discussions progress. KBDeX also produces temporal visualizations of network metrics, such as betweenness centrality, which indicates the extent to which a member influences other members of the group, and centralization of betweenness centrality, which indicates the extent to which the network is centralized. Within a Collaborative Innovation Network, oscillating patterns of betweenness centrality (i.e., rotating leadership) is considered a good measure of group productivity and creativity (e.g., Kidane and Gloor 2007).

2.3 Findings

In this section, group level analyses (temporal network analyses, discourse analysis) are reported to address the first set of research questions, followed by individual level analyses (social network analyses, content analysis) to address the second set of research questions.

2.3.1 Overview of Knowledge Forum Activities

Descriptive measures of online behaviors in Knowledge Forum indicate that students were working productively with ideas over the course of their inquiry. On average, each student wrote nine notes (range = 3–20), and used 8.7 key words (range = 3–15). The most common ideas discussed by students include: “cloud”, “evaporation”, “rain”, “sewer”, “air”, “earth”, “ocean”, “lake”, “snow”, and “sun”.

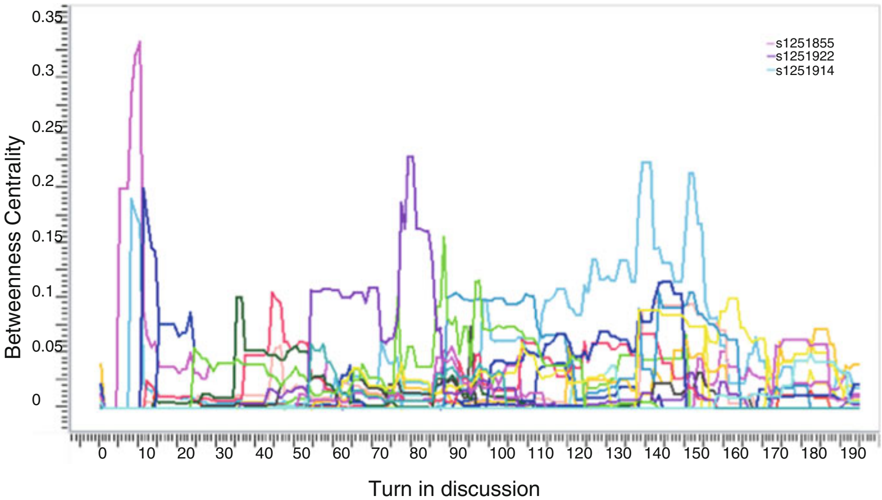

Fig. 2.2 KBDeX visualization of individual betweenness centralities across time

2.3.2 Temporal Network Analyses

The average centralization of betweenness centrality was 0.087 (range = 0–0.32), indicating that the network was relatively decentralized over time. Figure 2.2 shows temporal analysis of betweenness centrality for each student in the class. The Y axis of the chart shows the betweenness centrality value, and the X axis shows the turn in discussion over time. Each colored line represents a student, resulting in the display of 22 lines in the chart. The oscillation of colored lines depicts the phenomenon of rotating leadership, which means that the leading student (i.e., the student with the highest betweenness centrality) changed frequently. Of the 22 students, 13 students took a leading position, suggesting that many students were influential at different times. The topmost influential leaders were students s1251855 ($c_b = 0.356$), s1251922 ($c_b = 0.325$), and s1251914 ($c_b = 0.324$). While student s1251855 had the greatest influence in the student network, student s1251914 had the longest duration of influence in the student network.

2.3.3 Discourse Analysis

The student discourse in Knowledge Forum was arranged in chronological order to assess the collective trajectory of idea improvement and knowledge advancement. Each student note was coded along the dimensions of: (1) epistemic complexity (from unelaborated facts, elaborated facts, unelaborated explanations, to elaborated explanations) and (2) scientific sophistication (from pre-scientific, hybrid, basically scientific, to scientific). Whereas epistemic complexity represents the amount of cognitive effort exerted by a student to pursue theoretical understanding, scientific sophistication represents the success of a student to grasp a complex scientific idea (see Zhang et al. 2009 for details). In order to assess idea improvement at the group level, four notes were identified as pivotal points where the student discussion surrounding the topic of "evaporation" became increasingly scientific. Initially, students theorized that an intrinsic property in water, such as its weight, would help it float, while external forces, such as "gravity", would pull it down. When students started discussing weather systems, such as "rain", "snow", and "hail", they started theorizing that the "sun" and "heat" played a role in evaporation. Toward the end, students had a better understanding of states of matter and started explaining the water cycle in terms of "liquids", "solids", and "gases"; some even started investigating particle theory and talked about "molecules", "hydrogen", and "oxygen". The progression of their ideas parallels curriculum units in grades 2 (air, water, environment), 5 (properties of and changes in matter), and 9 (atoms, elements, compounds), respectively.

2.3.4 Social Network Analyses

Student s1251855 was the most influential leader. Figure 2.3 shows the network analyses in KBDeX when student s1251855 was leading. The student network in Fig. 2.3a shows that student s1251855 connected students s1251934, s1251914, and s1251918 to the larger group network. The note network in Fig. 2.3b shows that note 6 written by student s1251855, linked notes 1, 9, and 10 to the larger cluster of notes. The word network in Fig. 2.3c shows that student s1251855 connected the concepts of "air", "rain", and "plant" to the main discussion of evaporation.

Below is an excerpt of the student discourse in the Evaporation view when student s1251855 was leading. The problem of understanding, as indicated by student s1251860 is how water evaporates. Student s1251855 was the first to introduce the idea of "air" and "rain" in the discussion of evaporation, which prompted further discussion about the water cycle and weather systems.

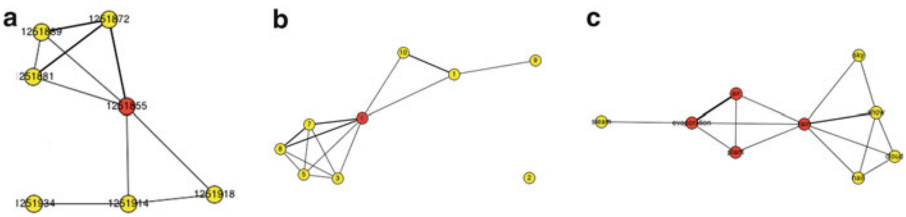

Fig. 2.3 (**a**) KBDeX visualization of student network, (**b**) KBDeX visualization of note network, (**c**) KBDeX visualization of word network at turn 9, when student s1251855 had the highest betweenness centrality

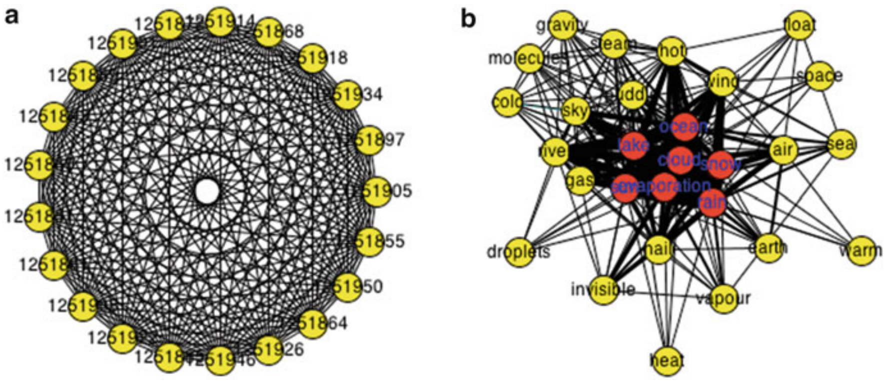

Fig. 2.4 (**a**) KBDeX visualization of student network, (**b**) KBDeX visualization of word network

s1251860: [I need to understand]: where does water go
s1251889: [My Theory]: I think when it evaporates it turns into steam
s1251881: [Important Information + source]: my dad told me that evaporation can do all sorts of things. I think that everyone is right because it can do all sorts of things.
s1251855: [My Theory]: I think that the water goes up into the “air”. It “evaporates” because it needs to turn into “rain” because “plants” need water and “rain”.
s1251918: [My Theory]: well…I think that the water goes up into the sky and comes down as rain and also comes down as snow.

2.3.5 Student Portfolios

Preliminary analyses of student portfolios were conducted in KBDeX in order to examine the extent to which student ideas were connected at the end. Figure 2.4a shows that all students in the student network are connected to one another, suggesting that students acquired shared vocabulary and reached a common understanding of water at the end of their Knowledge Building. Figure 2.4b shows that many ideas in the word network are densely connected. Ideas at the center of the word network include: “cloud”, “evaporation”, “snow”, “rain”, “sun”, “ocean”, and “lake”. Almost all students incorporated each of these ideas in their portfolios as they documented their individual knowledge advances.

Below is an excerpt from student s1251855’s portfolio:

> “I think the water “evaporates” up into the “clouds” and turns into “air” and when the “clouds” get too heavy with water it comes down as “rain”, “snow” and “hail” and it goes into the ground and then it makes groundwater. When it's in the ground, they make “lakes” and “ponds” and “puddles” and most of the water is covering the “earth”, but eventually it goes into the “ocean”. And then it starts all over again.”

2.4 Conclusions and Future Directions

Preliminary results confirm that this grade 1 class was indeed a successful Knowledge Building community, with students rotating leadership, actively improving ideas, all the while becoming a highly discursively connected community. Although only one example of leadership is reported here, similar results are found for the other top two leaders, and additional analyses with less influential students are underway in order to compare their learning trajectories.

The current study represents the first attempt to connect individual learning outcomes with rotating leadership at the group level during Knowledge Building. Recall that rotating leadership is an indicator of group creativity in COINs (Gloor 2005). Within the Knowledge Building context, it is interesting to note that when students assume leadership, they are connecting together unique ideas in the community knowledge, thus embodying the principles of *idea diversity*, *idea improvement*, and *rise above*. In other words, rotating leadership may be a useful way for teachers to identify students who are working creatively with ideas during Knowledge Building. It is possible that these students are facilitating the spread of improved ideas in the network or better yet, opening up new areas of inquiry for knowledge advancement. Further work is needed in order to understand how rotating leadership contributes to Knowledge Building across various contexts. Additionally, the role of the teacher needs to be examined to better understand how to facilitate self-organization around idea improvement. As in COINs, teachers and students in Knowledge Building communities are constantly redefining their membership as means to advance their community knowledge (Gloor and Cooper 2007). It is suspected that the role of teacher is to nurture swarm creativity and collaborative innovation in the classroom—a type of "disciplined" improvisation (Sawyer 2004).

In today's knowledge society, developing cultural capacity to innovate represents an educational priority. Knowledge Building pedagogy—informed by assessment designs from Collaborative Innovation Network theory—has the potential to transform classrooms into knowledge-creating communities, preparing students of all ages with competencies to communicate, collaborate, and innovate.

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