How Did a Grade 5 Science Community Co-Construct Collective Structures of Inquiry?

Dan Tao, University at Albany, State University of New York, dtao@albany.edu
Jianwei Zhang, University at Albany, State University of New York, jzhang1@albany.edu

Abstract: This study investigates how a Grade 5 science community co-constructed collective structures of inquiry in the form of "research cycles" to support sustained inquiry in a whole school year. Qualitative analysis of field notes, classroom videos, and student notebooks documented the evolution of research cycles. Analysis of student interviews showed how this structure was used and adapted by individual student to position and monitor knowledge progress and plan for further inquiry. Content analyses of student online discourse in Knowledge Forum indicated that students made more purposeful contributions aligning with the research cycle after formation.

Introduction

Over the past two decades, learning scientists have made major advances to explore how authentic inquiry and knowledge-building processes may be enabled among students to achieve deep and productive outcomes. Extensive studies have examined the social and cognitive processes of inquiry-based learning and knowledge building as well as teacher and technological scaffolding to support these processes (Bell et al., 2010; Hmelo-Silver, Duncan, & Chinn, 2007; Reiser, 2004; White & Frederiksen, 1998). Despite the conceptual insights developed, we, as a field, still face the challenge of how to bring sustained inquiry into classrooms to transform educational practices. To address this challenge, researchers argued for the need of a social practice perspective to support this line of work (Hakkarainen, 2009; Stahl & Hesse, 2009), which will address idea-centered knowledge building processes in conjunction with the cultivation of social practices that guide, channel, and sustain the participants' personal and collaborative efforts in creative ways. Current classroom practices to carry out inquiry-based learning tend to enact inquiry as a set of procedures to address pre-defined tasks and challenges. This routine-based notion of practices tends to underestimate the role of participants' agency and future-oriented imagination that drive dynamic changes of social practices. In real-world knowledge-building practices, participants continually build on and advance the knowledge assets of their community by generating and identifying promising ideas and improving the them through sustained inquiry and discourse; by formulating deeper problems as solutions are developed; and by assuming leadership and responsibility at the highest levels instead of relying on the leader to tell them what to do (Amar, 2002; Dunbar, 1997; Sawyer, 2007). They do not simply enact repeated procedures but also continually create and adapt their social practices as their knowledge is advanced (Knorr Cetina, 2001, Zhang et al., 2009).

This research explores a dynamic approach to inquiry-based knowledge practices drawing upon the Knowledge Building pedagogy (Scardamalia & Bereiter, 2006), a renowned inquiry-based program to cultivate authentic knowledge-creating practices. Different from many other inquiry-based learning programs in which students are required to work on predefined tasks/topics using step-by-step procedures and scripts, Knowledge Building adopts an idea-centered and principle-based approach to classroom design. Students and their teachers co-construct and reconstruct the flow of inquiry as their work proceeds guided by a set of knowledge building principles (Scardamalia, 2002; Zhang et al., 2011). A challenge arises pertaining to how the idea-centered, open-ended actions/interactions are translated into coherent and supportive classroom practices without extensive teacher pre-scripting. In light of social practice theories that highlight the interplay between human agency and social structures in sustained production and transformation of social practices (Giddens, 1984; Knorr Cetina, 2001; Sewell, 1992), our empirical analysis of how productive knowledge building communities identified an important socio-epistemic mechanism enabling sustained practices of knowledge building: reflective structuration by which students co-construct, adapt, and use collective structures to guide their collaborative work with ideas (Zhang, 2012). The collective structures serve as shared frames signifying structural properties of inquiry, including the epistemic objects/issues to be investigated as the focus of unfolding strands of practices (epistemic structure) (Knorr Cetina, 2001), productive ways to conduct research (pragmatic structure), and who should work whom in what roles (participatory structure) (Zhang, 2012). Students use such co-constructed structures to monitor and regulate their joint inquiry and position their roles and contributions. The purpose of this study is to investigate how a Grade 5 science community co-constructed the collective structures of inquiry in the form of "research cycles" to support an emergent trajectory of inquiry in a year-long initiative.

Method

Classroom contexts

The study was conducted in a Grade 5 classroom with 19 students (10-11 years old) from upstate New York in 2014-2015. The students investigated human body systems with Knowledge Forum (Scardamalia & Bereiter, 2006). Knowledge building practices in the classroom integrated individual and small group reading, whole class face-to-face conversations, individual and small group modeling and demonstrations, and student-directed presentations. Major questions and findings generated through these activities were contributed to KF for continual discourse.

Data sources and analyses

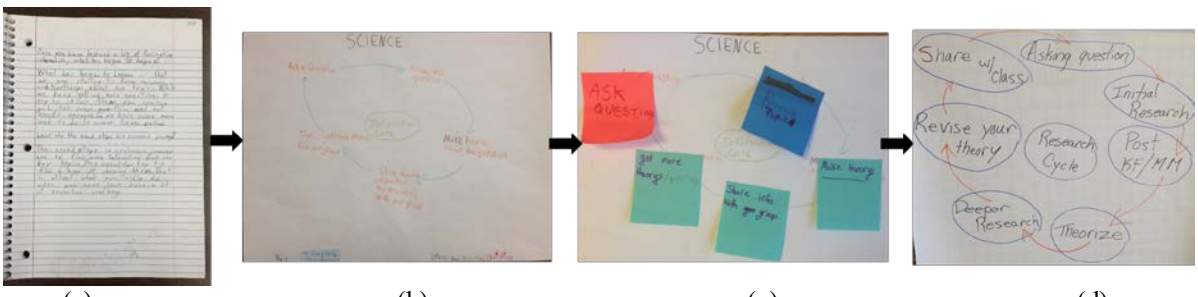
To understand the evolution of the "research cycles", we conducted qualitative analysis with rich classroom data. Reviewing field notes which recorded classroom activities in the whole year yielded the discovery of key events to zoom into. Classroom videos capturing these moments were transcribed and analyzed using a narrative approach to video analysis (Derry et al., 2010). Meanwhile, pictures of students' notebooks and classroom artifacts provided additional information about the processes involved in the process. In order to understand how students used the pragmatic structure after formation, we interviewed the students who agreed to share their comments. The interviews were transcribed, analyzed with open coding (Charmaz, 2006) and interpreted using a descriptive method.

To examine relationships between the actions in the research cycles and students' contributions to the collective discourse, we coded students' online discourse in terms of their contribution types (Zhang et al., 2011). In line with the essential actions on the inquiry cycles, the level 1 categories include *questioning, theorizing and explaining, collective evidence and referencing sources* as different ways of doing research, and *connecting/integrating* as an outcome of knowledge sharing. Under the level 1 categories, a set of codes capture more specific productive discourse patterns: *factual question* vs. *explanatory question; idea initiating wonderment* vs. *idea deepening question; intuitive explanation, alternative explanation vs. refined explanation, and evidence.*

Findings

Evolution of the research cycles over the whole school year

Analysis of field notes, classroom videos, pictures of students' notebooks, and artifacts created by students revealed the following main phases involved in the evolution of the research cycles (see Figure 1):



(a) (b) (c) (d)

Figure 1. Evolution of Research Cycles.

Phase 1- Reflection on individual journey of inquiry: In early November, when the teacher noticed students actively commented and built upon each other's ideas, he brought up the concept of research journey. With two questions provided by the teacher, each student reflected reflect on their own learning journey, in terms of where they were now and where to go next. Each student reflected on their previous inquiry and wrote down the answers in their notebooks (see Fig. 1a). Students first shared and discussed their answers in small groups. Later the teacher they organized a whole class discussion to share the reflection.

Phase 2- Co-generation and improvement of small group research cycles: Students worked in small groups and generated group-based research cycles according to their individual reflection on research journey and experience in collaborative inquiry. Most of the research cycles generated by small groups included some similar components (see Fig. 1b). Each small group used their own model to reflect on their knowledge building work and decided what they needed to do for deeper inquiry. After gaining deeper experiences with the inquiry process

in small groups, the five small groups revisited and updated their research cycles in mid-December, mostly to refine the sequences of the components and rephrase the components (see Fig. 1c).

Phase 3- Synthesis of small group research cycles into the collective research cycle: In the January of 2015, the teacher encouraged students to reflect on their previous research and develop a collective model of research that everyone can use to guide new research in the Spring. Students first identified the first three components: asking a question, initial research, and sharing online or in whole class meetings. After that they proposed and included four more components: theorize, research deeper, revise theories, and share within the class (then start over), leading to the finalized collective research cycle, which was hung on the wall for students to refer to (See Fig. 1d).

Phase 4- Adaptive use of the collective cycle by individuals and small groups: After formation, students revisit the collective structure from time to time in their subsequent inquiry. All the seven students interviewed thought the research cycle was helpful in guiding their knowledge building process. Analysis of their reflective comments on how they specifically used the research cycle yielded two categories: (a) following the cycle; and (b) adapting the cycle. A few of the students followed all the components in order when they investigated different topics. For example, some students mentioned: "*I did everything on the cycle." "All of the topics I did, I always did that order……*" Other students used the structure in a more adaptive way, like: using part of the cycle ("*I kind of using it... I did pretty much my own thing...*"); using as baseline to develop personal cycle ("*I would use the cycle to guide me...I would use just like baseline...I have my own research cycle*…); and using flexibly when needed ("*...my first question was schizo… the research cycle for me is kind of smaller. It can be larger if...*").

Knowledge building achievements in Knowledge Forum

We analyzed how students made various types of knowledge-building contributions as reflected in their online discourse before and after the emergence of the research cycles over the whole school year (see Table 1). Analysis indicated that before the discussion of the collective research cycle, the most visible online contributions were relatively broad explanatory questions about the body systems and generated intuitive explanations. After the negotiation of the research cycles that systematically highlighted a diverse range of specific knowledge building actions, students had a large number of posts raising idea-initiating questions and idea-deepening questions, elaborating ideas using referential sources of information, using evidence to support or challenge ideas, providing alternative explanations, and connecting and integrating ideas to develop coherent understandings.

Table 1: Students' knowledge building contributions in Knowledge Forum

Contribution Type		Before research cycles	After research cycles
1. Questioning	Factual question	8	8
	Explanatory question	45	18
	Idea initiating question	17	48
	Idea-deepening question	24	70
2. Theorizing/ explaining	Intuitive explanation	110	114
	Alternative explanation	13	34
	Refined explanation	31	29
3. Evidence		18	88
4. Referencing sources		24	167
5. Connecting & integrating		1	7

Discussion

This study examined how a Grade 5 knowledge building community worked together to co-generate a collective structure in the form of "research cycles "and used the structure adaptively to sustain productive knowledge building over a school year. Focusing on their initial questions and interests about human body systems, students first conducted inquiry based on their intuitive sense of the process of research as it had been loosely practiced in their prior schooling experience. As Table 1 suggests, their actions of inquiry typically involved asking broad questions about human body systems, generating intuitive explanations, and finding refined ideas using information sources. Reflecting on their initial journeys of research as individuals, small groups, and a whole community provided a dynamic social context by which the pragmatic structure of the research process emerged and was reified as formal research cycles. The emergence of the research cycles underwent several iterative cycles of reflective talks: students reflected on their journeys of research in small groups, and bootstrapping their reflective discussions, they made efforts to "peek" into the practices of scientists to adopt essential components of research. The research cycles of the small groups were shared and discussed in a whole class discussion and used by the small groups for a period of time. Based on their trial of their research cycles, students then reconvened

as a whole community to generate a collective model of research cycles, as a structure-bearing artifact. The teacher hung the research cycle model on the wall to ease its use. Through the intentional and adaptive use of the research cycles as a local structure of inquiry, students conducted sophisticated knowledge building practices as a community. The profile of knowledge building contributions in the community's online discourse was diversified in reflection of important components of the research cycles.

Aligned with the findings from our other study (Tao et al., 2015), this analysis guided by the adaptive structuration perspective contributes to understanding sustained knowledge practices driven by distributed student interactions without extensive pre-scripting. Clearly, deeper research on the teacher's role in facilitating the structuration process is needed to better understand such dynamics and shed light on specific designs to implement reflective structuration in classrooms.

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Acknowledgments

This research was sponsored by the National Science Foundation (IIS #1441479).