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Using Idea Thread Mapper to Support Collaborative Reflection for Sustained Knowledge Building

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Abstract

This paper reports a design-based study conducted in a Grade 5/6 classroom over two consecutive school years. Students of each year engaged in knowledge building in a scientific area using Knowledge Forum. The design innovation focused on engaging students in collective metadiscourse to review knowledge goals and progress with the support of Idea Thread Mapper (ITM): a timeline-based online discourse mapping tool. Using ITM students reviewed shared focal themes emerged from interactive discourse and identified ideas addressing each theme as a line of inquiry—an idea thread. Analyses of classroom videos, online discourse, and student interviews elaborated the processes of ITM-aided metadiscourse and its role in fostering student awareness of collective knowledge and dynamic idea interactions sustaining progressive knowledge building discourse.

Introduction

Various inquiry-based learning programs have been developed to engage students in authentic inquiry in line with creative knowledge practices that pervade many social sectors of today. The recent research on knowledge creation highlights it as a sustained and social process by which new ideas are continually developed, tested, refined, and built upon by peer researchers, giving rise to more advanced ideas and problems to work on (Sawyer, 2007). Inquiry-based pedagogy needs to similarly support such sustained, progressive, collective trajectories of inquiry to be productive (Engle, 2006; Hakkarainen, 2003). Students contribute diverse ideas to their ongoing conversations and collectively advance the ideas through constructive criticisms and mutual build-on, with new and deeper challenges identified as their understanding is advanced (Bereiter, 2002). Such discourse sustains over time across the boundaries of different activities of investigation; Ideas generated through experiments, critical reading, debates, and so forth are brought to the shared discourse for careful examination and further improvement, shedding light on opportunities for deeper investigations. This design-based research aims to develop classroom designs to foster such sustained dynamics of knowledge building supported by a new software tool—Idea Thread Mapper (ITM), which makes students' collective progress in online discourse visible for reflection. The classroom designs enabled by ITM engage students in metacognitive conversations to identify shared focuses of discourse, review progress of ideas contributed by various group members, and formulate deepening efforts as progress is made.

Integrating collaborative online spaces into classroom interaction helps to give student ideas an extended social life beyond segmented activities, so the ideas can be continually revisited, improved, and build upon by community members. Knowledge that grows in such shared discourse spaces represents a product of the community, as a whole—their community knowledge (Scardamalia & Bereiter, 2006) or group cognition (Stahl, 2006). Despite the above potential support, current online environments lack effective means to represent community knowledge in extended discourse, making it difficult for students to monitor and advance it. In threaded discussions and chatting, student ideas are distributed across individual postings over time (Suthers et al., 2008). It is hard for students to understand the conceptual landscape and unfolding trajectories of their collective work, causing short-threaded and ill-grounded discourse (Zhang, 2009).

This research explores ways to represent and foster collective trajectories of progressive inquiry in online and offline discourse. Our approach is informed by the view of collaborative knowledge building as multilevel emergent interactions in a dynamic social system (Sawyer, 2005; Stahl, 2013; Zhang et al., 2009). New knowledge is generated through dynamic interactions across the social levels of individuals, small-groups, and community over time. Interactive ideas contributed by individuals and small-groups connect and build on to one another over time, giving emergence to shared focuses, deepening goals, and advances. In interactive conversations, members dynamically maintain a shared focus of active consciousness, which constantly shifts and develops as the conversation proceeds. Interrelated focuses of conversation constitute larger focus clusters—discourse topics. “A topic in this sense is a coherent aggregate of thoughts introduced by some participant in a conversation, developed either by that participant or another or by several participants jointly…” (Chafe, 2001, p. 674) It is often presented in the form of a problem or gap yet to be filled that engages members’ thinking in an active and determinate psychic way. The evolving streams of the whole discourse are sustained through the joint interplay of the participants (Chafe, 1997). Dynamic teams or “knots” form, disband, and reform to address changing needs (Engeström, 2008; Zhang et al., 2009), altering the conceptual and social landscape of their community. Various focuses and topics contributed by different participants may be approached simultaneously as connected lines of conversation and inquiry. The whole course of inquiry unfolds in an emergent and improvisational manner, so it was not present in the minds of any participant before the inquiry. Meanwhile once the collective structures and goals of inquiry have emerged in a community and field, they have significant influence on how members and groups position their work and structure their roles and collaborations.

To represent emergent conceptual trajectories unfolding in extended discourse, we recently created a timeline-based collective knowledge-mapping tool: Idea Threads Mapper (ITM). Beyond micro-level representations of discourse as postings and build-on trees (physical conversation threads), we introduced idea threads (or inquiry threads) (Zhang et al., 2007) as a larger, emergent unit of ideas in online discourse. Each idea thread represents a conceptual line of discourse addressing a shared problem. It is composed of a chronological sequence of discourse entries (possibly in several build-on trees) contributed by a subset of the members of a community. Interoperating with Knowledge Forum (http://www.knowledgeforum.com, see Scardamalia & Bereiter, 2006) and potentially other collaborative knowledge building platforms, ITM supports shared regulation of knowledge building by engaging students in metacognitive conversations about their ongoing discourse. Different from primary discourse that focuses on the content, such metacognitive conversations (metadiscourse) help the participants to connect, organize, interpret, evaluate and frame their primary discourse (Vande Kopple, 1985). Sustaining knowledge-building discourse requires students to engage in metacognitive conversations to reflect on their community's ideas: to review various lines of inquiry emerged from members' interactive input, to monitor the state of understanding in the community as a whole, to diffuse new insights through the community, to make decisions for new and deepening directions of inquiry, and to identify more advanced goals over time (Scardamalia & Bereiter, 2006; van Aalst, 2009), and to re-organize their discourse spaces, group structures, and inquiry activities to best address their evolving goals (Zhang et al., 2009).

A pilot study was conducted in Grade 3 and Grade 5/6 classrooms to foster sustained knowledge building through ITM-aided metadiscourse, with promising findings (Chen et al, 2013). In such metadiscourse, students co-define focuses of idea threads based on themes identified from their knowledge building discourse, and then search and select important discourse entries (e.g. notes) for each idea thread. A graphical chart is then displayed showing the distribution of the notes on a timeline from the first to the last discourse entry (see Figure 1). Each idea thread can be updated and edited by adding or removing notes or highlighting important notes. Students can map out all the idea threads on the same timeline to examine idea progress and connection for a whole knowledge building initiative, identify threads with productive advances, and decide on areas that need deeper work. They co-author a "Journey of Thinking" reflection for each idea thread to synthesize focal goals, "big ideas", and plans for deeper inquiry. The results of the pilot study suggest the benefits of ITM reflection in fostering student awareness of collective knowledge progress beyond their individual focus and informing deeper efforts of inquiry to address weak areas and more challenging problems.

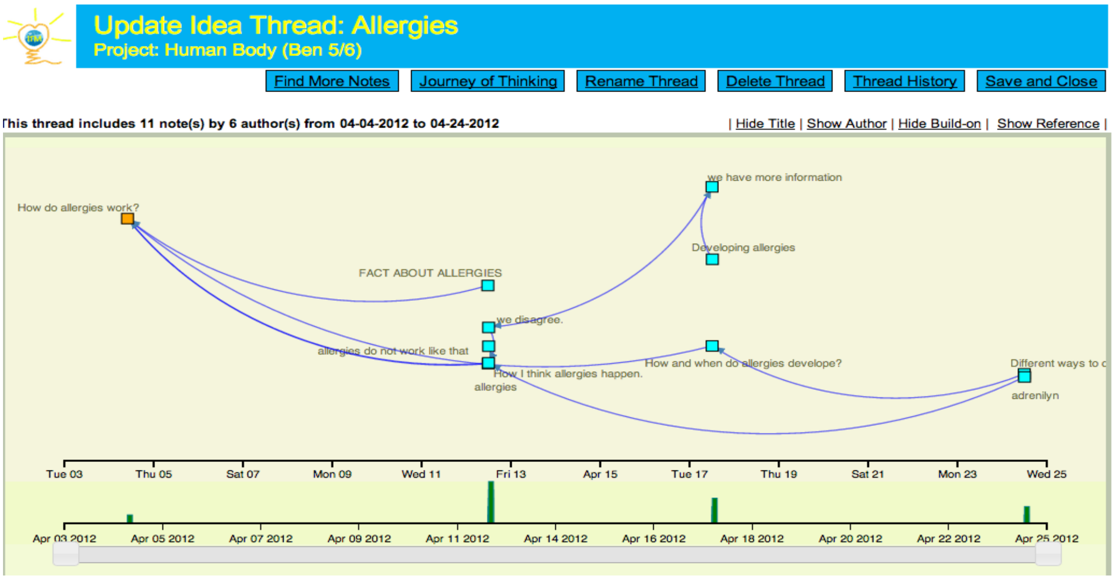


Figure 1. An idea thread on allergies created by a grade 5/6 classroom studying the human body. Each square in the thread visual represents a note, and a line between two notes represents a build-on link. Clicking a note will open its content. The user can choose to show/hide titles, authors, and build-on links and zoom into a specific time period.

Purpose of This Study

The purpose of the current study is to further test and refine ITM-aided metacognitive conversations to support sustained knowledge building. Our overarching research questions ask: how do students engage in collective metadiscourse to reflect on their community's knowledge building with the support of ITM? In what ways does such metadiscourse inform and foster sustained trajectories of knowledge building in a classroom community?

This Two-Year Design-Based Study

This research adopted a design-based research method to test and refine a focal classroom innovation in an authentic educational context through an iterative process, drawing on quantitative and quantitative data analysis (Collins et al., 2004). This two-year design-based study included two iterations and was carried out in a Grade 5/6 classroom taught by an experienced teacher who has been using Knowledge Forum and Knowledge

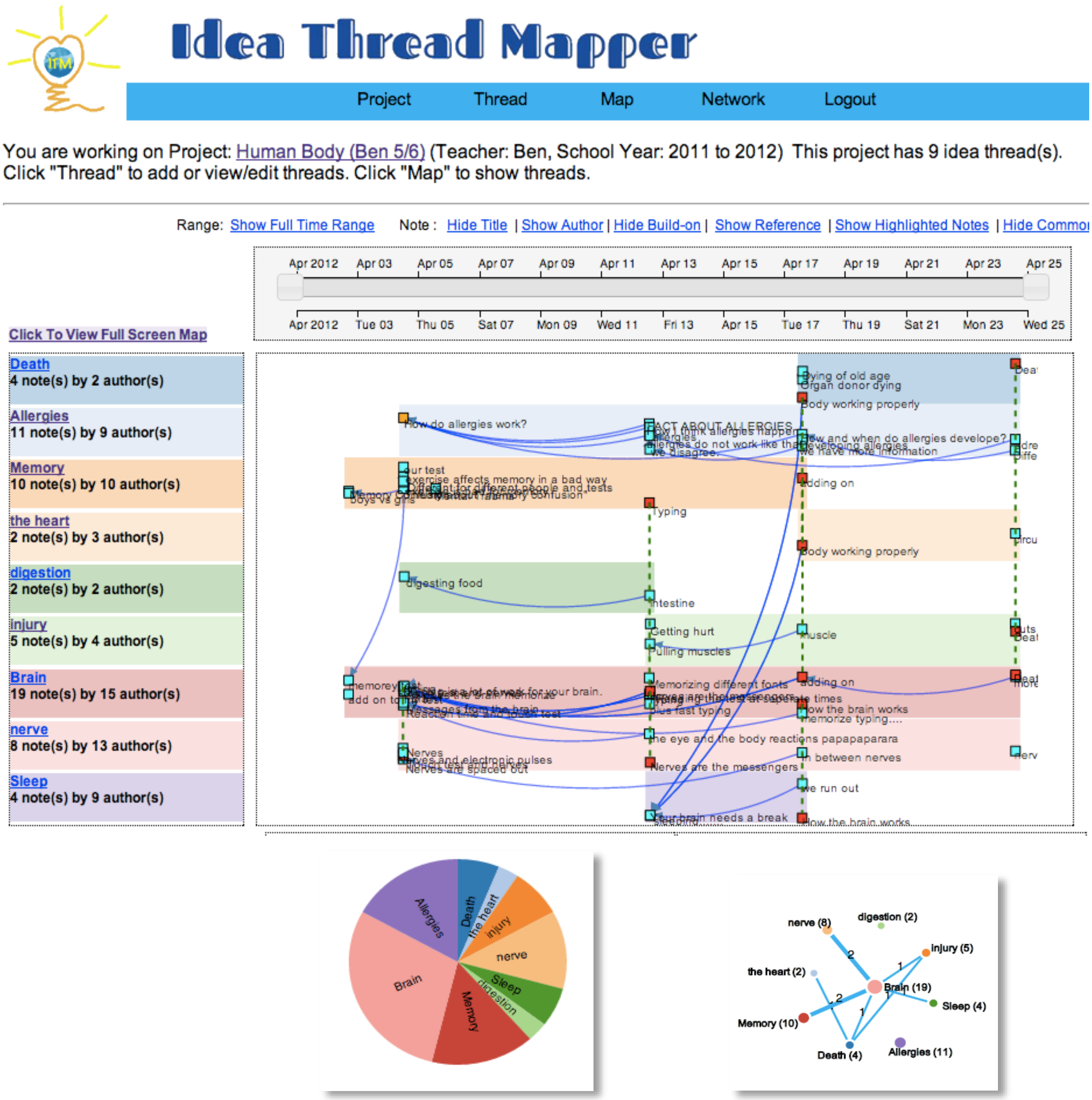
Building pedagogy (Scardamalia & Bereiter, 2006). In each of the two successive school years, the teacher worked with his students (n = 22) to investigate a science topic—the human body in Year 1 and electricity in Year 2—using approximately two months. Their knowledge building integrated whole class knowledge-building conversations, individual and group-based reading, student-directed experiments and observations, and so forth. Major ideas, questions, and findings were contributed to Knowledge Forum for continual knowledge-building discourse online.

The teacher encouraged his students to take on high-level responsibility to deepen the inquiry without pre-setting specific topics and procedures of inquiry. As the focal design innovation, students engaged in ITM-aided metacognitive meetings to review focal issues and ideas contributed in their knowledge building discourse, highlight shared goals, review progress of understanding, and plan for deeper work. Classroom data (e.g. videos, online discourse, student interviews) were collected to analyze how students engaged in collective metadiscourse using ITM, and the role of the metadiscourse in monitoring, sustaining and deepening their knowledge building. The design and results of Year 1 helped to inform refinements of the ITM tool and metadiscourse design in Year 2, which had more comprehensive data collected and analyzed.

Year 1: Elaborating the Design of ITM-Aided Collective Metadiscourse

Design of ITM-Aided Metacognitive Meetings

The work in Year 1 focused on elaborating processes of ITM-aided metadiscourse. It was organized as a two-hour ITM-aided metacognitive meeting in the fourth week of the human body unit that extended over two months. Students first identified "big ideas"—or "juicy topics" based on their memory of what had been discussed in their discourse. They then worked as a whole class to use ITM to identify important Knowledge Forum notes for a topic (i.e. allergies) to construct an idea thread (Figure 1). Temporary small groups were formed to construct idea threads for the rest themes. The session was concluded with a whole class conversation in which students examined the map of idea threads (Figure 2) to identify important advances as well as areas that required substantial efforts. The students then had continuous access to ITM as they conducted further work in the classroom and online.



Example analyses: Distribution of notes in threads | Cross-thread connection

Figure 2. A map of idea threads created by a Grade 5/6 classroom studying the human body. Each colored stripe in the upper map represents an idea thread extending from the first till the last note contributed addressing its focal problem/topic (e.g. how allergies work). Each square represents a note; a blue line between two notes represents a build-on link; a green

dotted line shows notes (in red) that are shared between different threads discussing interrelated issues. The user can hover the mouse over a note to see a preview of its contents and open an idea thread by clicking its title (left). The example analyses (bottom) show the distribution of notes in the different idea threads and conceptual connections between the threads based on the frequency of cross-thread shared/common notes.

Data Analyses and Results

The ITM-aided reflection session was video recorded. The videos were transcribed and analyzed using a narrative approach to video analysis (Derry et al., 2010). Two researchers first browsed the videos and transcriptions to develop an overall sense of the processes of ITM-aided metadiscourse, and then identified "digestible" chunks in the videos—major episodes of the reflective conversations by which students identified and negotiated "juicy topics," selected important discourse contributions, and planned for deeper inquiries.

The video analysis revealed collaborative interactions in the metacognitive conversation that gave emergence to focal threads of inquiry (see Chen et al., 2013 for details). The conversation began with the teacher highlighting the epistemic need to review and organize collective knowledge advances: *"In just about like three weeks, …we got 99 notes, and I was trying to look at this [Knowledge Forum view] today and I realize that...it's big and complicated… Um, I want to ask, … what are some big, 'juicy topics' that have come out here?"* The fifth- and sixth-graders co-identified core "juicy topics" based on their monitoring of ideas in the extended knowledge-building discourse. They proposed a total of 22 possible topics for the community to review, including allergies, nerves, sleeping, and so forth. These topics were proposed for collaborative review and screening to judge the importance, elaborate the scope of issues explored, and discuss their relations to other issues investigated. The teacher recorded the accepted proposals on a board. Some of the topics proposed were discussed and directly accepted by the community (e.g., allergies, death). Broad topics (e.g., brain) were elaborated and expanded to highlight the more specific focuses (movement, memory). A few topics proposed using intuitive language (e.g., getting hurt, bleeding, healing) were elaborated to clarify the deeper, scientific ideas (e.g., injury, immune system). Meanwhile, a few topic proposals, such as eye-booger and tears, were commented as minor issues. Through such reflective conversation, the whole class generated a collective list of 11 "juicy topics:" allergies, brain, sleeping, nerves, hair in skin, memory, digestion, death, injuries, heart, and muscles.

The students then worked as small groups to use ITM to review their online discourse about each topic, and selected important notes addressing each juicy topic to construct idea threads. With the map of all the idea threads (Figure 2) projected on a screen, student co-reviewed the idea threads to identify advances and weak areas. They looked at the length of each idea thread and density of build-on links, and discussed how the different lines of inquiry related to one another. For instance, by reviewing their idea threads map (Figure 2), students found that they had conducted intensive discourse about the brain, nerves, allergies as well as memory. They were surprised to realize that the thread on how the heart works, a very important topic, only had two notes, one of which was shared with the idea thread on death. Based on the co-reflection, students discussed areas that were interesting and needed deeper work, including the brain, nerves, heart, and sleep. Individual and collaborative efforts were then made to investigate issues related to these topics.

The results elaborate the process of collective metadiscourse with ITM to foster student reflection on collective knowledge progress and inform deeper efforts of inquiry. The young students were able to engage in metadiscourse meaningfully to review high-interest topics ("juicy topics") and progress. However, there was a lack of close connection between their metadiscourse in ITM and ongoing discourse in Knowledge Forum. It is challenging for students to identify "juicy topics" based on their memory of their discourse and inquiry and to focus their online discourse after the ITM reflection in line with the focal areas identified through their metadiscourse. Enabling more coherent and ongoing metadiscourse for knowledge building became the focus of Year 2.

Year 2: Refining the Design of ITM-Aided Metadiscourse and Testing Its Impact

ITM-Aided Metacognitive Meetings

In Year 2, design improvements were made to better ground the metadiscourse and connect it with student inquiry and discourse in Knowledge Forum on an ongoing basis. Students conducted the first session of ITM-aided metadiscourse and reflection in the third week of their knowledge building on electricity. With new progress made in their online and face-to-face work, they then conducted the second ITM session in the sixth week to revisit and update their ideas threads.

By the third week, students had created 88 notes in their Knowledge Forum view. In the first ITM session, the whole class first co-reviewed their Knowledge Forum view projected on a screen to identify high-interest topics discussed. Students were then given a print-out of their Knowledge Forum view, as an artifact to support more informed metadiscourse about their online discourse. They worked in small groups to examine the view to discuss "juicy topics" and mark out clusters of notes associated with each topic. The whole class then convened to share the topics identified, leading to the creation of a list of eight "juicy topics": batteries, static electricity, magnetism, electrons, atoms, voltage & charge, energy sources, and light. The students then worked in small groups each constructing an idea thread for a topic using ITM by selecting important Knowledge Forum notes contributed. As in Year 1, this session was concluded with a whole class conversation to examine the map of idea threads and reflect on important advances as well as weak areas.

With deeper inquiry and discourse carried out in the subsequent three weeks, students conducted a second ITM reflection session in which they revisited the map of idea threads to reflect on progress, updated each idea thread by including new Knowledge Forum notes addressing the deeper issues (Figure 3).

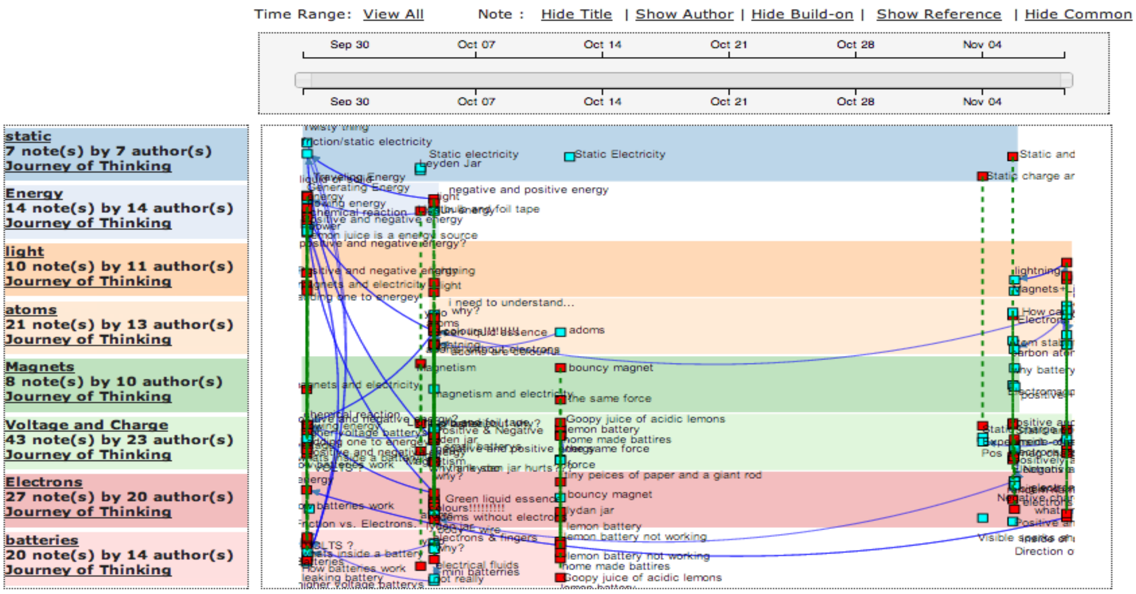


Figure 3. Map of ideas threads created through the first ITM session (mid-October) and then updated in the second ITM session (mid-November).

Consolidating their reflection, students further worked as small groups to create a "Journey of Thinking" synthesis for each idea thread using a set of scaffolds that highlighted problems of understanding, collective progress, and deeper issues to work on.

<u>Analyses and Results</u>

<u>Video analysis of ITM-aided Metadiscourse</u>**.** Similar to Year 1, the ITM-aided sessions were video recorded and analyzed, elaborating the multi-level emergent processes by which the community rose above diverse idea contributions in the online discourse to formulate collective goals and themes ("juicy topics") and reflect on progress. Using print-out of the Knowledge Forum view to support more informed metadiscourse eased student identification and negotiation of "juicy topics." After students marked out the topics on the view print-out, they shared the topics as a whole class, with the teacher writing down all their topics proposed on a board, resulting in a list of ten topics, including batteries, static

electricity, magnets/magnetism/iron, voltage and charge, energy sources, Leyden jar, atoms, electrons, positive/negative, light. Compared to the 22 topics proposed through the first round of review in Year 1, the above ten topics are much more informative, and suggesting that the students were better able to identify high-interest deep topics with the support of the view printout. The teacher then facilitated further reflection by asking: Are there any of these that …just fit like exactly together…like we don't need two different categories? Students suggested that positive and negative are related to electrons and Leyden jar should go together with static electricity. The analysis further elaborated the processes by which students co-authored "Journeys of Thinking" as small groups, with rich reflection evident in the small group process that helped to generate informative reflection in the "Journeys of Thinking." For example, synthesizing the thread on magnets, students highlighted:

> <***Our problems***>
>
> *We need to understand how magnets relate to electricity; …how do magnets work?*
>
> <***Big ideas learned***>
>
> *Magnets produce an invisible magnetic field. Magnets have two sides one positive one negative.*
>
> <***We need to do more***>
>
> *We should experiment with different types of metal to see which ones are more magnetic; We need to understand the connection between magnets and electricity by looking on the Internet…*

<u>Supporting Student Monitoring and Awareness of Collective Knowledge Advances.</u> More comprehensive data were collected and analyzed in Year 2 to examine the role of ITM-aided metadiscourse in helping students monitoring and advancing their collective knowledge. To examine the extent to which each student was aware of the knowledge

advances achieved by their community, we conducted an interview with each student after the first ITM session. The interviewer asked the students to first identify the major themes of inquiry explored by their community and then to summarize what they had understood about each theme. The interview was transcribed and analyzed using content analysis (Chi, 1997). Each student's reflection was coded based on topics addressed among a total of ten topics co-identified by two researchers. Ideas related to each topic were further coded based on scientific sophistication and complexity level using coding schemes developed through our previous studies (Zhang et al., 2007). Scientific sophistication examined students' ideas based on a four-point scale (1 - pre-scientific, 2 - hybrid, 3 - basically scientific, and 4 - scientific). Epistemic complexity indicates students' efforts to produce not only descriptions of the material world, but also theoretical explanations and articulation of hidden mechanisms, which are central to the focus of science (Salmon, 1984). A four-point scale (1 - unelaborated facts, 2 – elaborated facts, 3 – unelaborated explanations, and 4 - elaborated explanations) was used to code each idea unit (see Zhang et al., 2007 for reliability testing of these two measures). For comparison, we collected the same interview data from a parallel Grade 5/6 classroom that engaged in knowledge building using Knowledge Forum without using ITM (not until after the interview). The preliminary result of this analysis showed that students in the ITM class demonstrated understanding about broader topics ($M = 7.81$, $SD = 2.06$) than those from the comparison classroom ($M = 6.24$, $SD = 1.92$) (F (1,40)= 6.52, $p < .05$). Their ideas about such core topics were mostly coded as basically scientific explanations. Although there was no significant difference between the two classrooms in the overall complexity level of ideas across the topics ($p > .10$), ITM-supported students demonstrated more complex understanding about topics that are expected for higher grade levels, such as atoms, voltage and charges, and magnetic field.

Building Sustained Trajectories of Ideas to Address Deeply Connected Issues. In the online discourse students created 88 notes before the first ITM session and created 72 notes afterward to address deeper issues identified in their ITM reflection. Following idea thread (inquiry thread) analysis (Zhang et al., 2007), we used each thread topic as a "tracer" (Roth, 1996) to trace ideas contributed to the online discourse to understand how students' conceptual focuses and understandings evolved before and after the first ITM reflection session in relation to classroom inquiry activities observed. Such tracing and analysis was further extended to analyzing students' final presentations in which they shared deeper knowledge learned about the focal issues. The analysis identified several patterns by which the idea threads emerged and sustained in the online discourse.

(a) Deepening and refining: Experiential objects to be understood became focuses of discourse, leading to continual elaboration and deepening of ideas within each thread. The whole knowledge building initiative began with student hands-on exploration of light bulbs, wires, batteries, magnets, and different types of fabric to explore static electricity. Students then worked online to share their initial questions and ideas generated through the hands-on activities, allowing emergence to the idea threads about batteries, static electricity, and energy sources, and magnets. Sustaining these idea threads, students continually searched for deeper explanations beyond initial general thoughts and elaborated and refined their ideas over time. For example, students' initial ideas about how batteries work assumed that there would be "mini batteries" inside batteries; deeper and better theories were later generated focusing on chemical reactions inside batteries that cause movements of electrons, which carry negative charge. ITM-aided metadiscourse and reflection supported elaborating and deepening of ideas through explicating shared focuses of discourse, reviewing idea changes over time and highlighting deeper problems of understanding. For instance, reflecting on their inquiry of different fabric causing static electricity, students wrote in the "Journey of

Thinking": *"We need to learn more about static electricity because we don't have enough information about how it really works."*

(b) Rising above: Conceptual constructs emerged from deepening understanding became the focuses of new idea threads, giving rise to advancement of core conceptual frames. Exploring how batteries work led to the understanding that batteries have positive and negative poles. Discourse on fabrics that cause static electricity brought about concepts of negative and positive charges. Deeper efforts to understand the underlying mechanism of batteries and static electricity led students to understanding electrons and protons in atoms that carry negative and positive charges. In the first ITM reflection session, students identified abstract concepts such as charges/voltage, atoms, electrons as core topics of inquiry. Examining their map of idea threads (Figure 3) helped them notice deep connections between these threads and all other threads. Therefore, they identified electrons, atoms, and charges/voltage as the areas that needed deeper exploration. Important insights were generated in these threads after the first ITM session to understand these interrelated concepts: *"Electrons are the essence of charge. Atoms are the root of everything having to do with electricity." "Whenever you charge one thing positively, you are always charging the other object negatively. It's because the electrons move from one to the other."*

(c) Conceptual transfer and connection: Core conceptual frames and ideas were diffused across the community to advance the inquiry of different topics. Understanding electrical charges in terms of electrons and protons helped to leverage the online discourse in these thread after the first ITM and engaged almost all the students in the discussion. Atoms and electrons turned out to be the most frequently mentioned topics in the individual interview (21 of the 22 students). Core ideas generated in these threads were further transferred to the related threads of inquiry, such as to explain how static electricity works. Interestingly, even though no new note was added to the threads on energy and batteries after the first ITM session in mid-October (see Figure 3), these focuses were carried on in the threads on charges, electrons, and atoms to explore nuclear energy (e.g. atomic bomb) and how batteries work. Figure 4 generated through ITM shows such cross-thread idea connections. Students discussed and reflected on such cross-thread idea connections in the classroom to understand the deeply connected issues in this knowledge area.

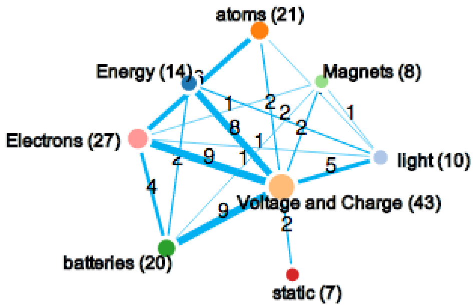


Figure 4. Notes shared between different idea threads. The number after each thread topic shows the total notes. The number on each link shows the number of notes shared between a pair of thread topics.

Discussion and Conclusions

To represent collective knowledge progress emerged from extended online discourse, we created ITM as a timeline-based collective knowledge-mapping tool. This two-year design-based research elaborated and refined the design of ITM-aided collective metadiscourse to review the state of understanding and discourse in a knowledge building community, to identify high-interest topics and advances, to diffuse new insights through the community, and to identify directions for deeper inquiry. Young students can engage in such collective metadiscourse meaningfully using ITM and with the scaffolding of the teacher who helps to facilitate a smooth flow between the metadiscourse and students' ongoing primary discourse online. The collective metadiscourse and reflection played a productive role in fostering student awareness and monitoring of their collective knowledge and emergent dynamic interactions for deepening inquiry. The analysis of the specific discourse patterns—refining and deepening, creating rise-above concepts, and conceptual connection and transfer—elaborate on the specific efforts leveraged by ITM reflection to sustain and deepen the collective trajectory of inquiry. We are currently conducting more detailed content analysis of the online discourse and final presentations to elaborate the idea improvement process and gauge the productivity of the community's knowledge building. In light of the research findings, we will refine the design of ITM to ease the flow between ITM and primary discourse environments (e.g. Knowledge Forum) and incorporate automated analysis to help students identify high-interest topics and related discourse contributions more easily (Sun et al, 2014).

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