The Idea-Friend Maps

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Abstract: This paper describes the development of representations based on a learning analytics tool, Idea-Friend Maps. It is designed to provide students with scaffoldings on three key questions that students may have when creating knowledge-creating dialogue: (1) How to work like researchers, to pursue different but related ideas? (2) How to identify the current state and future direction of the community knowledge? (3) How to create new knowledge by crossing knowledge boundaries? The inspiration is from the good moves in knowledge-creating dialogue proposed by Bereiter and Scardamalia. Moreover, from the *word* network exported from KBDex, three levels of Idea-Friend Maps are redesigned, including the group, community, and knowledge creation-levels. Furthermore, student inquiry into Idea-Friend Maps is integrated with social configurations (interactive and opportunistic collaborations). In addition to a conceptual framework underlying the Idea-Friend Maps design, this paper also elaborates upon the features of Idea-Friend Maps and reports the results of two cycles of implementation involving students.

Introduction

Equipping learners with capacities for knowledge creation and innovation has become a significant challenge facing education (OECD, 2017). *Knowledge Building* is a major educational-model in the learning sciences developed by Bereiter and Scardamalia (1993) based on decades of research. It focuses on knowledge-creation in a community as a collective effort. To support such creative community work, an online discussion platform, Knowledge Forum®, was designed to allow students to realize a series of knowledge works, such as posting problems, offering explanations, testing ideas, and conducting a sustained pursuit of inquiry, so that they can rise above and achieve collective advances (Scardamalia, 2002). Because of the central role of dialogue in knowledge-creating communities (Von Krogh, Ichijo, & Nonaka, 2000), promoting knowledge-creating dialogue is one of the urgent problems in the knowledge-building community. Thus, this paper provides a brief report of the development of representations from a learning analytics tool, Idea-Friend Maps (IFM), which focuses on the visualization of collective ideas on Knowledge Forum to promote knowledge-creating dialogue.

Knowledge-Creating Dialogue

Bereiter and Scardamalia (2016) proposed seven types of "good moves" for knowledge-creating dialogue, including *Problem Definition*, *New Ideas*, *Promisingness Evaluation*, *Meta-Dialogue*, *Comparison*, *Critical Discourse*, and *Higher-Level Ideas*. Great endeavors have been devoted to engaging students with good moves in knowledge-creating dialogue. For instance, to facilitate dynamic diffusion of *New Ideas* (i.e., introducing new ideas and integrating them with current community knowledge), Zhang, Scardamalia, Reeve, and Messina (2009) examined three kinds of social-configurations (fixed groups, interactive groups, and opportunistic groups). Opportunistic groups (students working temporarily in groups for emergent goals) were found to yield the best learning outcomes. However, further studies are still needed to explore how such emergent goals are created, just like researchers working in different groups but conducting research attachments because of common research

interests.

In other practices, *Meta-Dialogue* (reflective dialogue about dialogue) has been adopted to promote knowledge-creating dialogue. For example, Van Aalst and Chan (2007) designed an e-portfolio assessment tool with four knowledge building principles to help graduate students map collective ideas. Through the comparison between students' and experts' word networks, Resendes, Scardamalia, Bereiter, Chen, and Halewood (2015) intended to help students conduct classroom dialogue for identifying new lines of inquiry. Zhang et al. (2018) designed Idea Thread Mapper so that students could engage in meta-dialogue to review collective progress in extended online dialogue. Nonetheless, these examples above explored knowledge-creating dialogue only in small communities. Therefore, how to identify the current state and future direction among the large volume of online discussion notes created by large communities has aroused wide attention.

In addition, another strand of research has paid attention to the good dialogue move of *Comparison*, which denotes idea development across problems and community boundaries. For example, Yuan et al. investigated cross-classroom interaction, especially how new ideas were created in individual communities and improved by the cross-community dialogue, providing new insights into individual communities for further inquiry (Yuan & Zhang, 2020; Yuan, Zhang, & Chen, 2019). It is considered a novel design for Higher-Level Ideas (working collaboratively to develop an idea beyond the current state) by crossing community boundaries. However, from another perspective, creating new gaps and promising ideas on the boundaries of problems and theories might be another contributor to *Higher-Level Ideas*.

To sum up, substantial advances have been made in driving good moves of knowledge-creating dialogue through novel pedagogical and technological designs. Nevertheless, the following three questions deserve more effort: (1) How to work like researchers, to pursue different but related ideas? (2) How to identify the current state and future direction of the community knowledge? (3) How to create new knowledge by crossing knowledge boundaries?

KBDex for Visualization of Knowledge-Creating Dialogue

KBDex (Oshima, Oshima, & Matsuzawa, 2012) has been adopted in extensive research to visualize the process of knowledge-creating dialogue. KBDex is a learning analytics tool for visualizing the changing social networks of *student*, *word*, and *discourse*, as well as the centrality metrics of the three networks. For instance, in the study by Ma, Tan, Teo, and Kamsan (2017), betweenness centrality of the *student* network was employed to visualize the different expertise possessed by students, coupled with whether and how those different ideas were connected by rotate leaders (students with high values of betweenness centrality). Despite the application of KBDex to this research field, how to help students intentionally work as rotate leaders to pursue different but related ideas with the aid of KBDex should be taken into account.

To assess collective knowledge advancement, Oshima, Ohsaki, Yamada, and Oshima (2017) identified pivotal notes, which might be recognized as the current status of new knowledge, using the changing total degree centrality of *discourse* network. Furthermore, employing the *word* network for teacher professional development, Teo, Chan, and Ng (2018) expected to help teachers understand student collective discourse and reflect on how to further the boundaries of collective knowledge. Though KBDex was applied to these studies, how to help students identify the current state and future direction of the community knowledge by KBDex requires further exploration.

Moreover, the betweenness centrality of the *word* network was adopted by Yuan et al. (2019) to identify the new ideas developed through crossing community boundaries. In this situation, KBDex was also used by the researchers as well; however, additional efforts are still needed to figure out how to help students identify new promising ideas across knowledge boundaries by KBDex.

In conclusion, KBDex was adopted by researchers and teachers to visualize how relative ideas were connected, how collective knowledge was advanced, how new directions were identified, and what new ideas were created through boundary-crossing. However, little attention is paid to the application of KBDex by students. Thus, the design of external representations of KBDex is necessary for promoting good moves in knowledge-creating dialogue.

Embedded Knowledge-Creating Dialogue Moves in IFM

As mentioned before, Bereiter and Scardamalia (2016) proposed seven types of "good moves" for knowledge-creating dialogue. Some of them, such as *New Ideas*, *Meta-Dialogue*, *Comparison*, and *Higher-level Ideas*, are reconceptualized into the three key questions that students may have when creating knowledge-creating dialogue:

（1）How to work like researchers as a community, to pursue different but related ideas?

（2）How to identify the current state and future direction of the community knowledge?

（3）How to create new knowledge by crossing knowledge boundaries?

To assist students in answering the above questions, we export the *word* network from KBDex and redesign the external representations into three levels of IFM, which are the group, community, and knowledge creation-levels. Table 1 lists the types, and key features of IFM, together with embedded knowledge-creating dialogue moves and examples.

Table 1: Embedded Knowledge-Creating Dialogue Moves in the Three Questions

Questions	Types of IFM	Key features	Knowledge-creating dialogue moves	Examples
How to work like researchers as a community, to pursue different but related ideas?	Group-level	Highlighting ideas from other groups.	*Problem Definition, New Ideas, Promisingness Evaluation*	Students work in interactive groups to first identify their problems and then introducing new conceptions and promising ideas from related groups.
How to identify the current state and future direction of the community knowledge?	Community-level	Highlighting key problems of the community knowledge.	*Critical Discourse, Comparison, Promisingness Evaluation, Meta-Dialogue*	Students work in opportunistic groups to conduct meta-dialogue to criticize and synthesize different theories, identify connections between problems, and create new promising ideas.
How to create new knowledge by crossing knowledge boundaries?	Knowledge creation-level	Highlighting key problems in each research area to clarify knowledge boundaries.	*Comparison, Promisingness Evaluation, Higher-Level Ideas*	Students work in opportunistic groups to identify new gaps and higher-level ideas through crossing knowledge boundaries.

The Idea-Friend Maps

Unlike many other learning analytics tools designed for researchers and teachers, the three levels of IFM are specially designed for students. The word network exported from KBDex is the designed IFM. To provide a better picture of the IFM, we take the curriculum of the *Human Input & Output* as an example to present how students from a large Grade 5 community (n = 53) addressed the three questions under the three levels of IFM (Feng, van Aalst, Chan, & Yang, 2020). The study of the *Human Input & Output* is generally classified into eight science

domains: *Food Input*, *Excreta Output*, *Gas Input*, *Gas Output*, *Digestive System*, *Respiratory System*, *Cardiovascular System*, and *Others*.

How to Work Like Researchers as a Community, to Pursue Different but Related Ideas?

Figure 1 depicts a group-level IFM. The red and yellow circles denote those keywords that have already been and not been discussed by the group, respectively. Among them, yellow circles near the red ones represent "idea friends" (the "friendships" are among ideas), analogous to the proximity of scientific ideas in research. For example, students in the group, who took the responsibility of *Gas Input*, first identified "small intestine" as an idea friend of "food," and then moved to the *Digestive System* for relevant information.

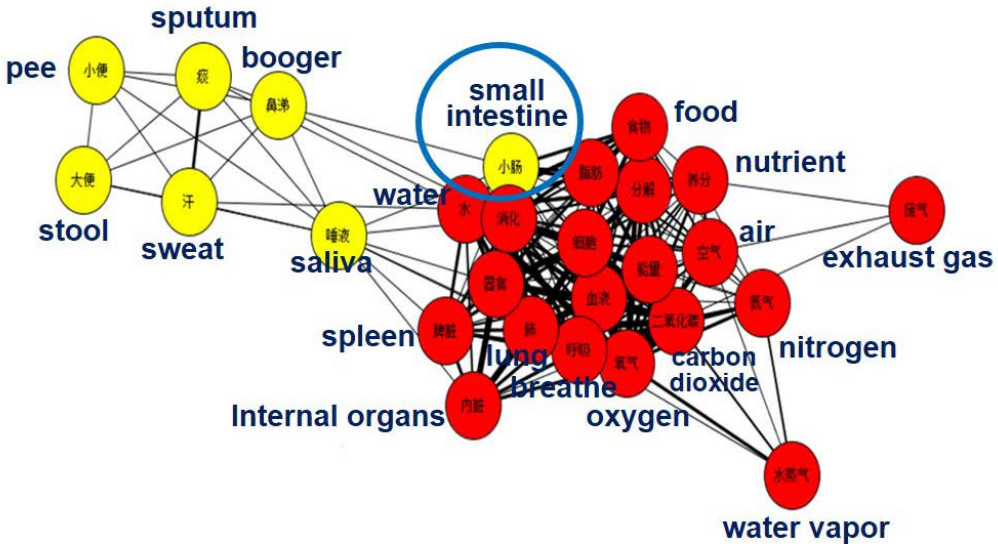

Figure 1. An example of the group-level IFM from a group who took the responsibility of *Gas Input*

How to Identify the Current State and Future Direction of the Community Knowledge?

A community-level IFM is present in Figure 2, in which the key problems identified by the community are denoted by colored circles (except yellow ones). For instance, the pink circle "nutrient" represents the key problem "How do people absorb nutrients?" It can be synthesized by students in opportunistic groups with the surrounding yellow circles.

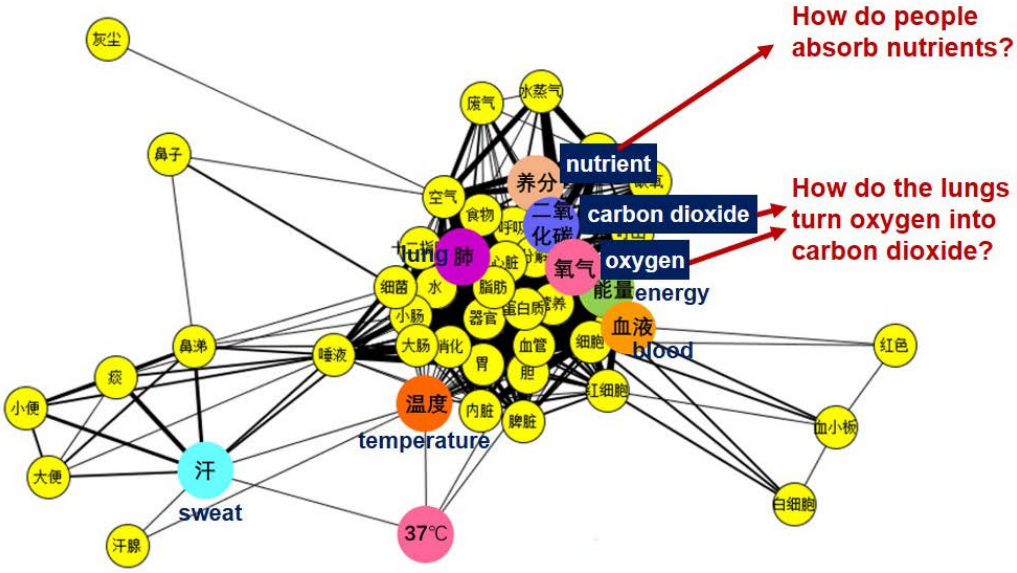

Figure 2. An example of the community-level IFM from a community

How to Create New Knowledge by Crossing Knowledge Boundaries?

Figure 3 displays the knowledge creation-level IFM. In detail, circles with the same color (except yellow ones) refer to the key ideas identified in the same problem. For instance, a new problem, "Why do we sweat after exercise but lose our body temperature?" is incurred by the connection between the red circle "exercise" and light blue circles denoting "sweat," "temperature," and "37°C".

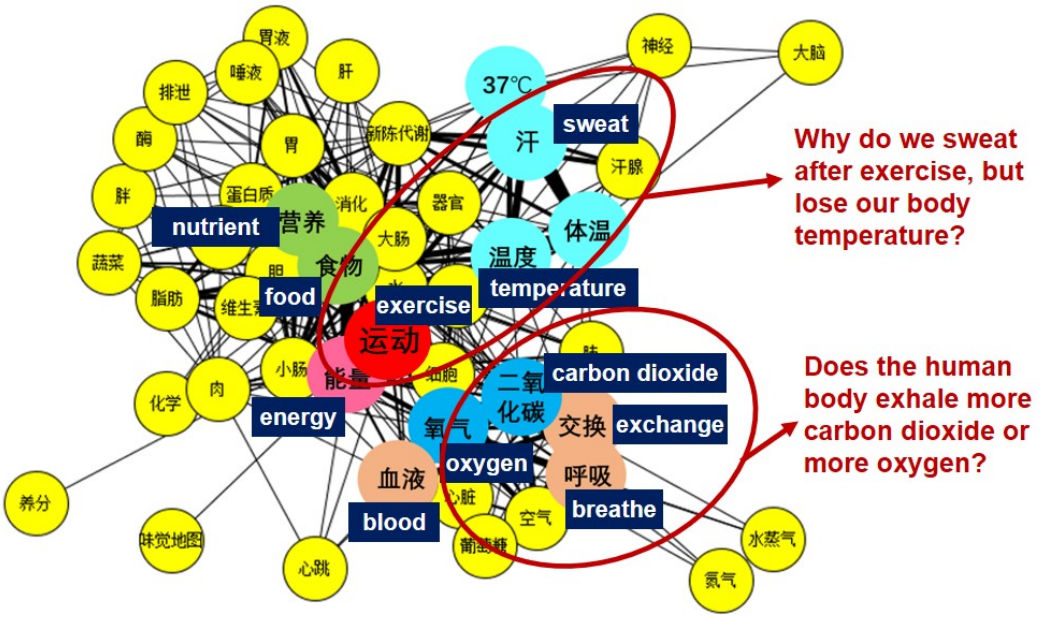

Figure 3. An example of the knowledge creation-level IFM from a community

Implementation and Results

Two-cycle design-based research was conducted among Grade 5 students when learning *Electricity* and *Human Input & Output* over two successive school semesters. It aimed to promote knowledge-creating dialogue under the three levels of IFM. Quantitative results indicate that students with the aid of the group-level IFM and community-level IFM, gained a better understanding of the science domain, achieved greater Knowledge Forum participation, and created more in-depth dialogue on Knowledge Forum than students from the regular class for the first cycle (Feng, van Aalst, Chan, & Yang, 2019). When the knowledge creation-level IFM was also implemented in the second cycle (Feng, van Aalst, Chan, et al., 2020), results reveal students' improvements in the understanding of the science domain as well as in their contribution to the collective knowledge advancement over time.

Furthermore, qualitative results indicate the group-level IFM scaffolded high and medium-contribution groups to advance collective knowledge through bridging knowledge; the community-level facilitated student groups' to carry out sustained inquiries; while the knowledge creation-level provided supports through synthesis, lending support, sustained inquiry, and further theory building (Feng, van Aalst, & Chan, 2020; Feng, van Aalst, Chan, et al., 2020).

Discussion

This paper reports on the development of the external representations of a learning analytics tool, which offers students the information about their changing ideas on Knowledge Forum using the redesigned *word* network from KBDex. The results from the preliminary implementation of the three-level IFM among Grade 5 students are encouraging.

Based on the proposed conceptual framework, the three levels of IFM present solutions to the three questions related to knowledge-creating dialogue that students may have. These three questions originated from the good moves of knowledge-creating dialogue (Bereiter & Scardamalia, 2016). Notably, their application is also integrated with the design of social configurations, especially the interactive and opportunistic collaboration. In the future study, more attention will be paid to the improvements of IFM and pedagogical designs, as well as how students develop progressive dialogue in the process of knowledge creation.

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