An Analysis of Collective Knowledge Advancement and Emergent Nature of Ideas in Subject-Matter Learning

Jun Oshima, Shizuoka University, joshima@inf.shizuoka.ac.jp
Takashi Tsunakawa, Shizuoka University, tuna@inf.shizuoka.ac.jp

Abstract: The idea emergence is a critical nature of collective knowledge advancement in collaborative learning contexts. Although recent advancement of data-mining procedure makes it possible to detect emergent ideas, classroom teachers also like to know how much their students engaged in the discourse around their study topics. In this study, we propose an analysis combining socio-semantic network analysis for collective knowledge advancement and data-mining for detecting students' ideas in their discourse.

Keywords: idea emergence, collective knowledge advancement, subject-matter learning

Background and research purpose

For analyzing student learning in the classroom from the perspective of knowledge creation, we need to develop a new analytic framework to capture collective knowledge advancement and the emergence of ideas through student discourse (Scardamalia & Bereiter, 2013). We have been developing metrics of student collective knowledge advancement in their discourse by socio-semantic network analysis (SSNA) (e.g., Oshima et al., 2012). Ordinary social network analysis (SNA) visualizes the social patterns of learners. As de Laat et al. (2007) suggested, this approach is informative when we examine developments or changes in the participatory structure of learners. However, several studies argued that existing social network models are not sufficient to examine how learners engage in their collective knowledge advancement through their collaboration (e.g., Schaffer et al., 2009). Instead, we used a procedure similar to ordinary SNA but proposed a different type of social network, one based on the vocabulary learners use in their discourse. We compared this socio-semantic network—in which words were selected as nodes representing learners' knowledge or ideas during a discourse on a study topic—with a network of words from the discourse of a group of experts on the same topic. The results showed critical differences in the collective knowledge of elementary school students and experts regarding the vocabulary centered on the networks. SSNA could provide a new representation of collective knowledge advancement, enabling researchers to adopt a new complementary assessment technique for investigating models of knowledge-building communities. In recent years, this SSNA approach has been adopted in CSCL studies to analyze student roles in collaboration and to detect productive interaction patterns (e.g., Ma et al., 2016; Oshima et al., 2012).

Studies in the field of learning analytics have accelerated the development of SSNA to analyze student communication online. One recent advancement in the field is the implementation of the data-mining procedure to select vocabulary for SSNA from natural discourse in collaboration (Lee & Tan, 2017). If we are more interested in the emergence of new ideas through learners' discourse, we cannot determine a list of vocabulary beforehand. The data-mining procedure can make it possible to detect vocabulary by which learners intensively use at any point in time of their discourse. On the other hand, however, when students are working on any subject matter, teachers are more interested in how much their students engage in the discourse related to the subject matter they study. If we use SSNA with the aim to examine student knowledge advancement in the subject matter, we should determine and use a list of vocabulary representing the study topic.

In this study, for solving the conflict in methodological approaches to examining idea emergence and learning of subject matter knowledge in the classroom, we examine student collective knowledge advancement in discourse by combining the advantages in both approaches discussed above.

Method

Study context

The target data in this study was student collective discourse in jigsaw instruction (Miyake & Kirschner, 2013). In the jigsaw instruction, three students in a group were given a challenge such as "Can you explain how vaccinations protect us from infections?" then provided three study documents, each of which was necessary for solving the challenge. In the first phase, one student from each group gathered to form an expert group and worked on their allocated materials over 1.5 lesson periods (each lesson period was 50 min.). After the expert group activity, students returned to their original group (the jigsaw group), where students had different pieces of knowledge to share and integrate for solving the challenge problem. This jigsaw activity took another 1.5 lesson periods. Group composition in both group activities (thirty-nine students in twelve groups) was designed by the teacher.

Data collection and analysis

We used two types of data for the analysis. The first was students' learning outcomes. The pre- and post-tests were conducted for evaluating their conceptual understanding. Based on their performance, we categorized each jigsaw group into high or low learning-outcome group.

The second data was video-record of their collaboration in the jigsaw group activities. Their discourse was transcribed for SSNA. In the first phase of our analysis, we calculated term frequency tf(t, d) of words representing students' understanding of the human immune system by using the following equation: tf(t, d) = 1 + log(ft, d). Then we further tested significant differences in the means of word vectors between the high and low learning-outcome groups. In the second phase of analysis, we visualized student collective knowledge advancement by SSNA with a list of vocabulary representing their study topic, human immunity system, and presented critical differences between the high and low learning-outcome groups.

Results and discussion

We found three high learning-outcome groups and nine low learning-outcome groups based on our criteria (Oshima et al., 2017). There were no significant differences in the means of tf word vectors among groups, $F(11, 198) = 2.35$, $p > .05$. SSNA revealed that students in the high learning-outcome groups were more engaged in transactive interaction such as building their ideas on others. With results of our analysis, we conclude that students who acquire higher learning-outcomes do not necessarily talk much about the study content but manipulate their ideas in the transactive way that are not usual in lower learning-outcome groups.

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Acknowledgments

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