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Teachers' Benefits of Using Social Network Analysis to Promote Scientific Argumentation

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<ABSTRACT>

The purpose of this paper is to investigate whether and how teachers could benefit from using social network analysis (SNA) in their science classrooms to promote scientific argumentation. Twenty-seven teachers (13 female, 14 male) participated in this study. The teachers developed SNA animation based on their scientific argumentation lessons. The main data sources, the teachers' interpretations of SNA, peer feedback, and interviews with the teachers, were analyzed and triangulated. The findings suggested that the teachers were not only able to visualize and characterize changes in classroom interactions over time using SNA interpretation, but they were also able to reflect on and shift their instructional methods to foster argumentation. SNA can help teachers identify, reflect upon, and develop instructional means to foster argumentation by enhancing their understanding of classroom interactions and facilitating open discussions about their teaching practices.

Key words : Social Network Analysis (SNA), Instructional strategy, Scientific Argumentation

Introduction

Engaging in argumentation based on evidence has become one of the eight practices that students must learn in K-12 science classrooms (NGSS, 2013). This emphasis on scientific argumentation, however, creates more challenges for teachers as teachers themselves hardly learn and teach argumentation in their lives (McNeill et al., 2016). Not surprisingly, high quality argumentation rarely occurs in science classrooms. To date, to promote scientific argumentation, research on scientific argumentation has focused on students' understanding of the language of arguments, namely, the structure and the elements of arguments. However, the influence of social relations in the classroom has been less explained. For example, the literature on collaborative learning suggests that social relation significantly affects how well and in what ways students interact with each other. Thus, teachers not only help students understand the language of arguments, but also must fully understand the classroom dynamics as well as the students' patterns of participation. However, it is not an

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easy task for teachers to understand social dynamics because they have to figure our such dynamics simultaneously as they teach.

In this context, this study proposes that social network analysis (SNA) could be a useful tool for teachers to visualize and understand changes in classroom interactions and dynamics over time. SNA is currently being used to describe and understand participation patterns in various classroom interactions as well as instructional patterns. For example, SNA is used to examine peer influences on youth behavior (Ennett et al., 2006), the degree to which educational games can be used for knowledge construction (Shaffer et al., 2009), and the nature of teacher networks (Penuel, Riel, Krause, & Frank, 2009). By utilizing SNA, teachers can observe and track changes in an individual or a group's participation over time, which can help them reflect upon their teaching practices. In particular, this study sought to answer the following research questions:

1) When SNA is used in argumentation instruction, how do teachers use SNA to track patterns in, and make changes to, classroom interactions?
2) How do teachers use SNA to reflect upon their roles and positions in the classroom?
3) When teachers discuss their experiences with SNA with other teachers, do these experiences help the teachers critically reflect upon how their teaching practices promote scientific argumentation?

Background

Promoting Scientific Argumentation

Before discussing how to promote scientific argumentation, it is important to note the reasons for promoting scientific argumentation in science classrooms. Cavagnetto (2010) found that the prevail purpose of including scientific arguments in science classes is to enhance the understanding of science contents. This purpose is consistent with making thinking visible. From this view, students can see what they think more clearly as they engage in argumentation, and thus they can learn science contents better. Learning the language process of arguments is the second emphasis. However, for these emphases, Berland and Reiser (2009) criticized that the original purpose of constructing and revision of scientific arguments, “persuasion” from the perspective of scientists has been missed. To learn persuasion as the main goal of scientific argumentation, Berland and Reiser highlighted the importance of social interactions and dialogical interactions, in which students could experience the need of persuading other people. Ryu and Sandoval (2012) suggested that the appropriation of persuading goal might not be easily achieved, as epistemic authority belongs to teacher traditionally. Thus, they suggest that the opportunities to persuade others need to be naturally embedded in ongoing science activity, instead of giving structural scaffolds. In doing so, students may feel the need of persuasion, before they learn how to persuade.

To support students' argumentation, teachers should be able to teach the structure and the element of arguments. But perhaps more importantly, teachers also should be able to trigger, facilitate, and coach students' argumentation so that students naturally need to feel the need of persuasion to make a consensus. To trigger, facilitate, and coach students' argumentation in an effective way, teachers have to understand who with whom, when, and how students interact each other.

Social Network Analysis

SNA analyzes either the structure of the relationships or the positions of the individuals in a network (Wasserman, 1994). To be used as an analytic tool, SNA essentially assumes that the individuals who are members of the network are shaped by its organizational structure. Based on network and graph theories, SNA shows who knows whom and who shares what with whom how often by utilizing connected nodes and lines. As a result, the relative positions of the individuals or groups are represented by the number, shapes, and lengths of the ties and paths connecting them. In such a way, SNA can gauge the relationships between different social entities.

Social Network Analysis in Education

SNA has recently started to be used more frequently for a variety of purposes in educational settings. For instance, Ennett and his colleagues (2006) investigated how peer influences affect youth behaviour. Shaffer and his colleagues quantified the different types of epistemic variables in an epistemic network by adopting ideas from social network designs, while Penuel and his colleagues (2009) used a social capital theory perspective to investigate the role of teacher interactions in reforming schools. They illustrated how the network perspective allowed the teachers in the study to understand the overall social structure of the school and the social resources that were being exchanged through their interactions with other teachers. Nevertheless, while SNA is used for the post analysis of interactions and social structure, little is known about how it could be used to enhance the design of learning environments. In particular, this study investigated how teachers use SNA to improve their teaching practices.

Understanding Social Interactions and Dynamics when Teaching Scientific Argumentation

Science teachers need to understand classroom dynamics as well as patterns of participation when teaching scientific argumentation as it is by nature a highly interactive social practice. To be more specific, teachers need to know who participates actively, what roles each student tends to take when engaging in science experiments, what the group dynamics of the different groups look like, and so on. Furthermore, they should be able to diagnose and evaluate the effectiveness of the instructional strategies or methods they use to promote argumentation. While a teacher might be able to observe or keep records of a couple of students at a time, it is difficult for a teacher to continually keep track of the changes in participation in the classroom as a whole because the teacher is not a mere observer, but also the main actor who leads the various kinds of class activities. Moreover, it would be impractical for a teacher to simultaneously see, analyze, and triangulate the changes in participation as well as any other changes such as changes in conceptual knowledge and the effectiveness of the resources used.

Pre-developed observation protocols are often used to help teachers understand classroom participation as well as learning concepts and science skills. While such protocols are useful in assisting teachers to understand certain types of interactions, the complexities of the protocols are difficult to grasp and use as they tend to be written for well-trained observers rather than teachers. The fact that observation protocols are likely to require several items to be checked within a short period of time further hinders the efficacy of their use in the classroom.

SNA may allow teachers to see and analyze the overall changes in the social structure of the classroom while using new resources or instructional methods at the same time. For example, SNA allows a teacher to see what is happening by examining the flow of available artifacts or knowledge. In short, SNA actually shows what the social structure and concomitant interactions look like and how they change over time instead of requiring the teacher to interpret what is going on. For example, a teacher may want to record the changes in a student's participation in a group and in the classroom over time. Without using SNA, the teacher would need to describe the student's changing participation behaviors or rely on the relevant observation protocol; however, either method constitutes a type of second-hand data that reflects the interpretation of the observer, in this case, the teacher. On the other hand, SNA can show what is going on and how the interactions around the student are changing in real time. That is, if the student (a node in an SNA) has many links to other students (nodes), it will mean that the student has many interactions as represented by the number of links to other nodes. The addition of the variable of tenure allows another level of interpretation. For example, for a certain amount of time, the node may seem to have more links to the other nodes in a group rather than outside the group, suggesting that the student is active and plays a central role in the group.

By quantifying the number of relationships (links among the nodes) and time, SNA also allows teachers to observe and diagnose other types of participation changes, such as bottlenecks or breakdowns in participation. While these types of participation are likely to be caused by unfair social classes (ethnic, economic, academic, etc.), student interactions often look similar as such power-related dynamics also exist in student group interactions.

Understanding Student Group Argumentation: Using a Clique Analysis

To observe the changes in a classroom or small group discussion, a clique analysis (Aviv, Erlich, Ravid, & Geva, 2003; Ryu & Lombardi, 2015) can be used. A clique analysis represents the characteristics of the sub-groups in a main community to shows how dense the connections developed from simpler dyads or triads are. Such developments should be of interest to teachers who might want to trace the development of argumentation within a group. A “clique” is a smaller set of networks inside a bigger set in which the agents are more linked and tied together than with the other members in the network. In a classroom activity or discussion, if a clique is centered around one node, it could suggest that a student is dominating the targeted activity. In a classroom, the teacher or an academically better-performing student may tend to be observed as the single, central node.

In argumentation situations, if an SNA shows that a dyad or triad has grown into several cliques that include different central nodes, it could suggest that active and distributed argumentation has occurred.

Method

Study Design, Settings, and Participants

Twenty-seven teachers (13 female, 14 male) participated in this study. These teachers had volunteered to participate in a professional development course. The professional development course was designed to utilize technology-enhanced instructional methods to promote student argumentation. While these teachers were somewhat familiar with teaching argumentation in science classrooms as they had used Next Generation Science Standards (NGSS) over the previous two years, they had never used SNA to interpret student interactions or to communicate their classroom reflections.

Data Sources and Procedure

The main data sources were teachers' interpretations of SNA that had been videotaped, peer-reflection reports as well as interviews with the teachers. During the professional development program, which continued over a period of two weeks and comprised 7 hours in total, the teachers first learned how to develop and interpret SNA animation. The instructor of this program (the author) also showed the teachers a series of demos that consisted of SNA tutorials and shared them with the teachers via YouTube.

Each participant's 15-minute science seminar with their students was video recorded and digitalized. Each science seminar comprised a developed science activity that promoted scientific argumentation by assigning different roles to the students in the discussion and rotating these roles. The interactions on the video were developed as SNA animations using Social Network Animator (SoNIA). SoNIA is a software application that visualizes dynamic and longitudinal network data and renders them as animations. These SNA animations were subsequently shared with the participants for further reflection and discussion.

Each participant reviewed their own videotaped lesson and wrote a short reflection paper. The reflection paper included the goal of the lesson, the instructional methods and/or strategies designed for argumentation, and any other reflections. The participant also compared the videotaped lesson with the SNA animation.

Each participant then presented selected components of the SNA animations, relevant clips of the video, and their reflection paper to the other members of the professional development course. After each presentation, the teachers freely discussed the issues and interesting features that had emerged.

After the presentation, each participant was interviewed by the author of this study. The interview consisted of three main parts: the teacher's background in teaching scientific argumentation, their assessment of using the SNA animator, and their reflections of the peer-SNA discussions.

Data Analysis

The objectives of the analysis were twofold. First, the aim was to identify how SNA was utilized so as to understand the changes in the teachers' argumentative interactions. Because the teachers had learned about clique analysis, interaction frequency, and length of time as the main factors of SNA, the analysis focused on how these interpretations were reflected in their changing roles (e.g., as a presenter, facilitator, and defender) when participating in the argumentative science seminar. Second, the analysis focused on exploring the subsequent peer feedback that the teachers had exchanged. The presentations as well as the discussions among the teachers were recorded. The video analysis software Transana (Wood, 2005) was used to develop a rough version of the log files attached to the video clips. Based on these log files, aspects that were of analytic interest were chosen for further analysis. These aspects, which were determined by the author, reflected changes in the relevant teacher's interactions and/or argumentative discourse, and the teacher's disposition when observing the SNA animation. The teachers' interview data were triangulated with the video observations.

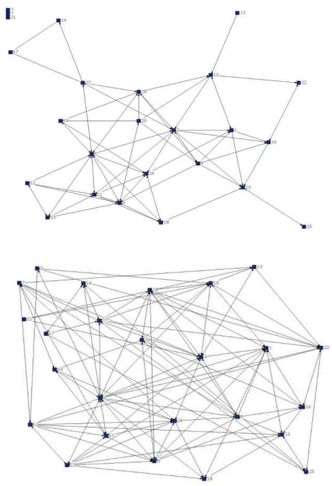
Findings

When SNA is used in argumentation instruction, how do teacher use SNA to track patterns in, and make changes to, classroom interactions?

The teachers reported that, by using SNA, they were able to discover which students were more isolated and which students took central roles. One teacher noticed that different cliques, namely smaller sets of networks inside a bigger set, were being generated after she decreased her time with the students to the extent that she only gave direct instruction and assigned different cognitive roles to her students. Her method served as a model case study and led the other teachers to decide to adopt similar methods for teaching argumentation.

(a)

(b)



[Figure 1] (a) Initial student interaction (b) Student Interaction after changing teacher's role (3 months after)

For example, Figure 1. (a) shows that 3,7, and 21 students never talked to any other in the classrooms. 17, 14 and 21 students talked to only one another. 13 talked to 15 only. 25 talked to 10 only. The teacher reflected that she mostly talked with the main figures of the network, and hardly paid attention to other students. She reflected that she was satisfied with her classroom's discussion because the discussion was still active. But, she realized that it was her misunderstanding after constructing her classroom's SNA because it revealed that only a few students talked too much, and others did not. To promote her classroom's argumentation, she decreased her entire classroom talk and discussion, and encouraged her students to talk in small group discussion. At the same time, she gradually decreased her interruption and scaffolds, and let her students discuss and argue, within a group, between groups, and at the entire classroom level.

How do teachers use SNA to reflect upon their roles and positions in the classroom?

Teachers first constructed a SNA of their own classrooms. From the analysis of initial SNA of their classrooms, many teachers were surprised by the patterns of their classroom interaction and dynamics. While they somehow guessed the existence of the dominant, the isolated, and small cliques in a classroom in general, they rarely expected that such social relationship patterns could affect the ways in which students participated in scientific argumentation. Teachers' responses vary according to their teaching strategies. Some teachers used an explicit way to manipulate classrooms' participation. They intentionally decreased the dominant students' opportunities to talk, and encouraged other isolated and less participating students to talk more. Some teachers, like Jane in the example above, tried to change their participant structure, instead of direct interruption of participation. One teacher began to use a rotation method, in which every student takes a different role in science classes such as a planner (students who prepared a scientific investigation), presenter (students who present their results) and explorer (students who conducted a scientific investigation).

When teachers discuss their experiences with SNA with other teachers, do these experiences help the teachers critically reflect upon how their teaching practices promote scientific argumentation?

At first, teachers shared what they were able to identify from their SNAs with others because most teachers dealt with SNAs for the first time. Identification of isolated students was the most common feature noticed from SNAs, which led to active discussion regarding how to deal with these students. While some teachers insisted more affection and interest are necessary for them, others said that it is a common thing in classrooms, and a teacher cannot take care of participation of every single student in a classroom. While the research team encouraged teachers to construct SNAs as many as possible during 3 months, most teachers except one teacher constructed two or three SNAs. It is probably because construction of SNAs requires intensive labor. At the end of three months, teachers agreed that more opportunities of small group discussion in the context of collaborative investigation increases argumentation. To foster more and broader engagement among students, teachers agreed that decreasing entire classroom discussions as well as increasing small group activities is a good strategy. Teachers mentioned that figuring out old-friends from the previous year and avoiding putting them in a same group would be a good way to disassemble cliques. Teachers agreed that SNAs of classrooms could be a useful way to figure out participant structures and social relationships. However, they also indicated that constructing SNAs by themselves took too much time.

Concluding Remarks

This study shows a possibility of using SNA in science classrooms to promote scientific argumentation by encouraging more engagement among students. After analyzing SNAs of their classrooms, teachers selected various strategies to promote scientific argumentation. Teachers were not only able to visualize and characterize changes in classroom interactions over time as they interpreted their SNAs, but also that they were able to reflect on and shift their instructional methods to foster argumentation. In addition, their shared experiences of using SNAs seemed to motivate the teachers to engage more in the reflection and discussion of their teaching practices with the other teachers. Therefore, using SNA can help teachers identify, reflect upon, and develop instructional means to foster argumentation by enhancing their understanding of classroom interactions and facilitating open discussions about their teaching practices.

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Revised in April 30, 2015
Revised in January 01, 2017

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The aims of the Brain, Digital, & Learning are to promote the research and to exchange updated research results timely among science education communities and interest groups by presenting the results of scientific education researchers and to provide administrative support for science education scholars, science educators, and science education in the fields of Brain based Education, Digital Textbook, Smart Education, Cognition, and Learning.

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1. The journal is published four times a year. [03. 31., 06. 30., 09. 30., 12. 31.]
2. Research articles submissions is always possible throughout the year, and the journal is published on March 31, June 30, September 30, and December 31 of each year.

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   1) Title : Malgun Gothic, letter size 16, set width 100, spacing -15, deep, center arrangement
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(unit : person)

	distribution	collection	analysis
elementary school	400	320	315
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total	550	410	401

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