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Analyzing CSCL-mediated Science Argumentation: How Different Methods Matter

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Abstract: Research on argumentation has increased our understanding of knowledge construction, group learning, and scaffolding structures in CSCL although analyses of argumentation pose many difficulties. This could be due to the many theoretical positions that can be taken when approaching discourse data. In this paper, we use three popular analytic methods (interactional, content-specific, and linguistic) to compare the same fragment of scientific argumentation by Grade 4 children in Singapore. We show the complementary emphases and strengths of each disciplinary position as well as their weaknesses. The results imply that analytic methods arising from different disciplinary positions can potentially broaden our overall understanding of using argumentation in CSCL.

Introduction

Argumentation is an important research problematic in CSCL. Perceived to be a key feature in promoting deep understanding through group learning, CSCL studies have generally focused on the potential of technology to support productive argumentation (Andriessen, 2006). Invariably, studies on argumentation have focused on student discourse (e.g., Mirza, Tartas, Perret-Clermont, & De Pietro, 2007; Schwarz & De Groot, 2007; Weinberger & Fischer, 2007), and hence analysis often makes use of turn by turn interactional methods. However, there are other theoretical positions of interest such as the content-specific and the linguistic positions. For example, science educators are mostly interested in the construction of scientific arguments and development of concepts that are consistent with the established science community. Analysis of students' science argumentative discourse thus focuses on the substantive *content* of discourse rather than its *process* (e.g., Kelly, Regev, & Prothero, 2008; Sandoval & Millwood, 2005, 2008; Simonneaux, 2008). Linguists, on the other hand, favor the organizational structure of the argumentative genre and analysis here takes place at a more macro level of textual structure.

These theoretical positions that range from micro-genetic turn-taking to macro-structural levels of organization of content do present difficulties of analyses when using a popular framework like Toulmin's Argument Pattern (TAP). These problems include identifying the unit of analysis and differentiating the components in the framework (e.g., Erduran, 2008). While we are aware that each method of analysis will yield useful results, we seek to determine what these divergences are and how they together contribute towards a fuller picture of argumentation. In the following, we discuss an argument framework based on TAP and apply three popular methods of analyses—Interactional, Content-specific, and Linguistics—to study the same fragment of scientific argumentation among three Grade 4 students in Singapore. We found that the different and incommensurable units of analysis inherent when using the three frameworks resulted in alternative categorizations of students' ideas. Our findings broaden our overall understanding of using different analytic methods when studying argumentation in CSCL.

Theoretical Framework

In this section, we discuss different definitions of an argument and an argument framework based on Toulmin's Argument Pattern from different theoretical lenses. The purpose is to show how different theoretical positions may affect the analytical lens taken in studying a piece of argumentative discourse.

An argument can be considered a product and a process, constructed individually or socially (Jimenez-Aleixandre & Erduran, 2008). It is an individual production if we think of it as a piece of reasoned discourse. For example, a scientific argument is a particular genre produced by a scientist to convince others of his/her point of view. It is characterized by unique rhetorical structure and organization, defined by the social practice of science community (Scheppegrell, 2004). To achieve scientific literacy, in this case, is to be able to produce the rhetorical features in persuading and convincing others of one's point of view.

An argument can alternatively be thought of as a social process if we consider it as a chain of reasoning or different positions that people can adopt. While the second definition is often associated with opposition and aggression, and often considered as interference to learning, collaborative argumentation can be a powerful vehicle in developing critical thinking (Andriessen, 2006). It offers an opportunity for individual ideas to be externalized and challenged, leading to refinement of ideas and deeper understanding. In science, the social process of argumentation had allowed ideas such as the Plum-pudding model of an atom to be challenged as new evidences were brought in to refute it, leading to refinement of the theory to what is presently known as the

Rutherford's planetary model of atomic structure. In other words, argumentation is an important process of knowledge building. Since arguing is a form of inquiry, it is considered a form of learning (Koschmann, 2003).

A third perspective of argumentation comes from specific content disciplines such as science education. A key focus here is the development of conceptual understandings similar to the acceptable norms of the scientific community. Argumentation is perceived as one important means for this goal as its social nature allows students' cognitive processes to be made public so that any misconceptions can be clarified to align students' thoughts with the scientific community (Jimenez-Aleixandre & Erduran, 2008).

Argumentation Framework

A framework commonly used to study argumentation is Toulmin's Argument Pattern (TAP) which describes the structure of an argument as a set of interconnected claim, evidence, warrant, backing, qualifier and rebuttal. A claim is defined as a statement of assertion put forth for public acceptance. Evidence is a piece of specific empirical or theoretical data used to support a claim. Warrant, backing, qualifier and rebuttal are parts of reasoning to provide a link between a claim and a piece of evidence. However, this six-element framework is very complex to those applying this model to analyze the form and structure of arguments (Williams & Colomb, 2007; Erduran, 2008). Instead, a three-element framework, *claim – reasoning – evidence* (C-R-E), proposed by Williams & Colomb (2007) simplifies the original framework to capture the essential dimensions of an argument without separating its components too finely. Nonetheless, other problems still persist such as distinguishing the components of C-R-E: What counts as claims, evidence and reasoning? Another problem lies in the difficulty in identifying the unit of analysis: Is it a clause, turns of talk, or the whole text? These problems often lie with the different theoretical positions in analyzing an argumentative discourse as we now explain.

From a linguistic lens, analysis of genre takes a *grammatical* approach. Analysis involves studying the use of language resources in the construction of a text to look for language patterns and organizational structure of the genre (Derewianka, 1996; Painter, 2001). For example, an argumentative text will consist of predictable features such as the use of connectives and purpose circumstances such as *first, second, so that, as a result, and because*. Therefore, the unit of analysis for studying genre should be at a micro-genetic clause level, conducted for each turn of talk.

Unlike this linguistic micro-genetic approach, a social theorist takes a more macro approach towards discourse analysis (Sawyer, 2006; Stahl, 2006). Taking each turn of talk as its unit of analysis, interaction analysis looks at the *social function* of each turn of talk between interlocutors. Interaction analysis categorizes each turn of talk by taking into consideration the previous and next turn of talk. The I-R-E (initiation-response-evaluation) is a typical example of an interaction analysis of classroom discourse.

While the above two methods of analyses focuses on the processes and functions of each turn of talk, discipline-specific educators are more focused on the achievement of *content-based learning* outcomes. For example, science educators are concerned whether students acquire the same set of ideas consistent with the scientific community or the extent to which student talk resembles the structure of a science argument. Analysis now involves studying the types and quality of knowledge in an argument. For example, Sandoval and Millwood (2005) looked at how students coordinated data and science knowledge to justify their claims. The unit of analysis for dialogic argumentation is the individual utterance where content is emphasized.

To summarize the three analytic methods (i.e. Linguistics, Interactional, and Content-specific), each analysis method has its own focus and hence, the unit of analysis differs. When these methods are applied to the *same* fragment of online argumentative dialogue, we show (1) the differences in outcomes, and (2) what strengths/opportunities and limitations/threats arise in each. In the next section, we will give a brief account of the background of the online discussion that is being analyzed.

Method

In this study, we applied three methods of analysis to the same fragment of discourse among three elementary school students and their teacher. This discourse is part of an online discussion whereby the three students (Henry, Yvonne, Mary) were discussing how the presence of plankton and algae in a reservoir affects the amount of dissolved oxygen in the water. This discussion is a follow-up activity where they previously collected data on water turbidity and made observations about the types of organisms found there. The online discussion platform used, Knowledge Forum, is an asynchronous CSCL system that supports students' collaborative discourse through public display of ideas to encourage intersubjective meaning making (Scardamalia & Bereiter, 2003).

Findings and Discussion

This section reports the analysis of online discourse among the students and their teacher using different analytical lenses: (1) Linguistics, (2) Interactional, and (3) Content-specific. It also discusses the strengths and limitations of the three analysis methods in helping us make sense of a discourse from an argumentative framework.

Comparison of Coding Results using Different Analysis Methods

The online discourse is taken from a thread of discussion centered on Henry's response (note 2) to the question posed by the teacher (note 1). Table 1 shows the coding of this discussion thread using different analysis approaches.

Table 1: Coding of online discussion thread.

Note	Author	Content	Coding based on different analytical lens		
			Linguistics	**Interactional**	**Content-specific**
1	Teacher	I need to understand How the presence of plankton and algae may affect the quality of water (amount of oxygen)?	Question seeking causal explanation	*Questioning*	*Questioning the manner of a process*
2	Henry	The algae floats on top of the water and blocks sunlight from getting into the depths of the water	Stating cause – effect	Responding with certainty	Giving Reason
3	Yvonne	I need to understand how will the algae floating on the top of the water affect the amount of oxygen?	Question seeking causal explanation	*Questioning*	*(Question seeking claim)*
4	Mary	Maybe the algae prevent the air from escaping	State effect (with hedging)	Responding with uncertainty	Giving Reason
5	Teacher	I need to understand how does algae prevent air from escaping?	Question seeking causal explanation	*Questioning*	*(Questioning the manner of a process)*
6	Mary	My Theory the algae takes in the air that is going up to the surface of the water	Stating cause	Responding with certainty	Giving Reason

When a linguistic lens is used to study the turns of talk, it shows that the genre of each turn of talk is mainly one of explanation. The participants in this discourse were trying to construct a causal explanation for the effect on the quality of water caused by the presence of plankton and algae in the water (see Note 1). The resulting notes (2, 4 and 6) were trying to address the question with supporting questions seeking further elaboration of the effects or the causes resulting in the phenomenon. For example, in Note 2, Henry attempted to explain how the location of the algae results in sunlight being blocked. However, he did not go further to describe the effect on the amount of oxygen as a result of sunlight being blocked. This could be the reason why Yvonne asked for further causal effect on the amount of oxygen when "the algae floating on top of the water" (Note 3). Therefore, in these few turns of talk, the purpose of each turn is to elicit or give a causal explanation for the phenomenon raised by the teacher in Note 1.

Through the lens of interaction analysis, the interaction pattern was mainly question-answer. This is evident in the excerpt whereby each question (Turns 1, 3 and 5) was immediately followed by a response, which in turn, was followed by another question.

From a content-specific perspective, in which the accuracy of content and argumentative structure is important for achieving the learning outcomes, an expected model answer to the teacher's question in Note 1 is as follows, with the idealized structure of a science argument identified in brackets.

> The presence of plankton and algae in the water reduces the amount of oxygen in the water *(claim)*. This is evident by the low oxygen level measured in water with lots of algae and plankton found *(evidence)*. This is because when plankton and algae fill the water, photosynthesis cannot occur as they block sunlight from reaching the water plants at the bottom of the reservoir. Besides, algae and planktons also respire, taking the oxygen in the water. *(reason)*

In this analysis, categorization of ideas was made in relation to the question initiated by the teacher in Note 1. Since the question required the students to make a claim that connected the presence of microorganisms (plankton and algae) and the amount of oxygen in the reservoir, students' ideas were coded as a claim if the students' note related the microorganisms to the amount of oxygen in the reservoir. An idea was coded as evidence if some empirical data was put forth. Any scientific principles or theories that related the

microorganisms with light and photosynthesis were considered as reasons. With this form analysis, we found that the ideas put forth by the students were mostly reasons. Ideas in Notes 2, 4 and 6 were describing how algae affects sunlight going into the depth of the reservoir (Note 2), which is essentially the principle of light not able to penetrate through opaque objects, and the condition needed for living things (Notes 4 and 6), which is based on the conditions for living things to survive. In relation to the question asked in note 1, there were no explicit claims made about how these processes may affect the amount of oxygen in the reservoir even though Note 3 seemed to be eliciting for one. There was also no mention of any empirical data collected from the reservoir.

In short, we found that the coding results of an argumentative discourse arising from different analysis methods provided different information about the discourse taking place.

Strengths and Weaknesses of the Three Analytic Methods

The findings of this study show that different analysis methods resulted in different coding results. While each analytic method has its strengths, the different foci also limited what it reveals of an argument. From a linguistics approach, we see the structural form of the argumentative discourse constructed by the students. It revealed which components of an argument are co-constructed by the students and which aspects of an argument were still lacking. For example, the discourse among the three students was made of mostly personal responses about the causes that affect the quality of water. However, they did not identify the eventual effects of the presence of microorganisms on the quality of water. If the intent of the online discussion was to provide the platform for science argumentation, the resulting explanatory genre demonstrated in these turns of talk shows the commonsense knowledge that students tend to use when they have not mastered the rhetorical structure of a scientific argument. From a cultural perspective, these students have not been inducted into the social practices of the science community (Scheppegrell, 2004). In other words, a linguistic approach to analysis is useful in informing the extent in which students have appropriated the social norms of communication within a particular community. Such findings are useful in providing information of the kinds of technical scaffolds needed to induct students into the social practice of the community. Limitations of a linguistics approach lie in its lack of focus on interpersonal relationship and correctness of discipline-specific content in the co-construction of knowledge. Understanding these aspects is better informed by interactional and content-focused methods.

While the linguistic approach provided information about the structure of the argumentative discourse, the interactional method informed the process of meaning making among the students. It revealed the role of each note in the co-construction of an argument. For example, the analysis of the three students' interaction showed that the students were merely responding to each question put forth individually. While each question attempted to elicit an elaboration of the previous response, it was answered by the students in isolation, without attempting to connect with previous responses from others. This lack of connection or elaboration of answers made each response appear like a claim, which could be further challenged or questioned. The superficial notes could be a reason for the failure to sustain a discussion (Hewitt, 2005). From this example, it shows that an interactional method is useful in revealing the process of meaning making (or the lack of it). This information is useful for designing scaffolds to help students construct a more in-depth argument with their ideas so that a more sustainable discussion can go on. The limitation of an interactional analysis shows that the types of knowledge and depth of explanation are not well understood. A content-specific method is thus more useful for this purpose.

The findings from a content-specific approach show how students made use of very specialized forms of knowledge appropriate for a particular community. For example, in the sample online discourse, it showed that ideas put forth in Notes 2, 4 and 6 were based on scientific facts and extending it to the process in which they will affect the environment conditions such as "algae … blocks sunlight from getting into the depths of water" and "the algae takes in air". While these may be considered as claims by themselves, they are also reasons when analyzed in respect to the questions asked in Notes 1, 3 and 5 as the ideas explain the process which will affect the amount of dissolved oxygen in the water. However, there were no explicit claims made about the amount of dissolved oxygen in the water in the presence of algae and plankton. This could be the case where students were more confident in putting forth knowledge they knew empirically or from past experience rather than threading on new grounds (i.e., making new claims). Results of a content-specific approach are, therefore, helpful in identifying the types of knowledge that students' ideas draw from, which in turn, inform the epistemic beliefs of the students (Sandoval & Millwood, 2008). Such findings are helpful in directing how intervention could be applied to help students make use of different sources of information, including their own beliefs, in knowledge building. The limitation of content analysis is that it does not capture the textual organization of an argument or the social process of knowledge building.

Conclusion

In this paper, we demonstrate the different aspects of an argument through a short fragment of online discourse, uncovered by different analysis methods: linguistics approach informs structural organization, interactional approach informs the process of co-construction of the argument and content-specific approach informs the

types of knowledge used in forming the argument. Adopting one method solely or exclusively presents a partial picture of how an argumentative discourse brings about knowledge building. Our findings highlight the necessity in having multiple analytic lenses when examining complex data in CSCL. Together, these three analytical lenses have the potential to broaden our understanding of how argumentation can be used as a valuable form of knowledge building in CSCL.

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