Online Discussions as a Tool to Engage Students in Authentic Scientific Argumentation

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ABSTRACT

The purpose of this research is to explore various aspects of scientific argumentation as it occurs both face-to-face and on asynchronous online discussion boards. Engaging students in authentic scientific discourse is considered a primary goal of science education, but there are many challenges to accomplishing this in the classroom, and potentially even more challenges in an online environment. Online discussion boards are potentially valuable instructional tools, but little is known about the science learning that occurs via discussion boards. This research’s goal is to bridge the intellectual circles examining scientific argumentation and online learning to provide a greater understanding of how to engage students in scientific argumentation using online tools, namely the asynchronous discussion board.

Keywords

Science education, scientific argumentation, online discussion boards, inclusiveness.

INTRODUCTION

REVIEW OF THE LITERATURE

Learning institutions are increasing course offerings and enrollment in online courses (Nandhi et al. 2012), while at the same time, science educators are encouraged to move away from the traditional passive lecture and towards using methods that promote active learning, such as use of student-response systems (i.e., "clickers") and discussion among students (Allen & Tanner 2005, Handelsman 2004). Discussions are an important learning activity because they address the fourth strand of scientific literacy defined by the National Research Council (2007), to participate in scientific practices and discourse. Also, the recently released Next Generation Science Standards explicitly include the scientific practice "engaging in argumentation from evidence" as an essential element of K-12 science curricula (National Research Council [NRC], 2012, p. 52), thereby demonstrating its centrality to all scientific disciplines. Scientific argumentation, regardless of the particular discipline, is a particular type of discourse in which scientists apply evidence, theory, and converging lines of reasoning to make a scientific claim and persuade an audience to accept the claim (Jimenez-Aleixandre & Erudran 2008). Through engaging in evidence-based discussions in class, students potentially mirror the form of scientific discourse that is used by scientists and therefore work toward becoming enculturated into the community of science. The challenges to compelling students to engage in scientific argumentation are numerous and will be outlined shortly. The purpose of this research is to explore various aspects of scientific argumentation among students as it occurs in both face-to-face and online learning environments, with the overarching goal to discover ways that challenges can be overcome in both environments.

Discourse Patterns

Berland and Reiser (2009) have identified three discourse patterns in which students can potentially engage during scientific argumentation: sense-making, articulation of ideas, and persuasion. Students often view sense-making and persuading as mutually exclusive and thus engage in one or the other (Berland & Reiser 2009). This results in either claims not backed by
evidence or unaddressed inconsistencies between students’ arguments (Asterhan et al. 2010, Berland & Reiser 2009). Several suggestions have been put forth about why this occurs. Berland and Hammer (2012) suggest that students do not cognitively frame the classroom activity so that they perceive all three discourse patterns as acceptable classroom behaviors. For example, during a class discussion, instructors expect students to talk to each other and form arguments that their peers find convincing, but students have been schooled in a system that has led them to frame classroom activity as sitting quietly, looking to the instructor as an authority figure, and forming arguments that the teacher finds convincing, not necessarily their peers. The implied solution then, is to create classroom communities that have a set of norms and that enable students to frame these discursive practices of sense-making, articulation of ideas, and persuasion (between peers) as acceptable and desirable behaviors in that classroom; these are behaviors that youth readily engage in outside of school (Moje et al. 2004). Exploring how these norms can be established in both face-to-face and online environments is one goal of this proposed project.

Asterhan et al. (2010) suggest an alternative explanation about why students resist sense-making or persuasion when discussing science topics with their peers. To understand their point, it is important to realize that when a student engages in sense-making, he is “thinking out loud,” is not necessarily certain of the ideas being put forth, and is simply trying to make sense of information given, as the name implies. In other words, engaging in only sense-making means there is always an “out;” the speaker never commits to an idea so there is little risk to ever being wrong. When engaging in persuasion, conversely, a student is trying to persuade another that she is right and the other is wrong. In doing so, there is no “out;” so if she does not want to appear wrong, the only choice is to “stick to her guns” and maintain the claim, despite counter-evidence. Asterhan et al.’s (2010) explanation of students’ inclination toward either sense-making or persuasion is that their engagement in scientific argumentation is mediated by their perceived relative status. In other words, students are afraid to lose face, so inconsistent claims are not mentioned and/or persuasive efforts are not relinquished even in the face of convincing counter-evidence. Presumably relative status could be based on a number of things, such as perceived competence in the subject matter or perceived social status. Asterhan et al. (2010) have termed this phenomenon socio-cognitive conflict. This hypothesis corroborates evidence from our recent study (in revision) in which we found that during discussion tasks, most naïve conceptions expressed by students went unchallenged by their peers, but students asked for additional information following an unscientific claim more often in online discussions than when face-to-face. While we did not have evidence to claim this was conclusively due to socio-cognitive conflict, our data is certainly supportive of this notion. In this project, we are interested in how perceived status affects students’ ability to engage in “productive” scientific argumentation both online and face-to-face. By our definition, productive scientific argumentation has three components: 1. students engage in all three discourse patterns (i.e., sense-making, articulation of ideas, persuasion) at some point in the conversation, 2. students take into account evidence (including counter-evidence) in making claims, and 3. students show some indication of conceptual development in the science concepts being discussed.

**Discourse Regulation**

Daron et al. (2002, 2007) have defined two types of discourse regulation that are likely to determine if students engage in productive scientific argumentation. These are epistemic regulation and relational regulation, and these describe what compels a student to engage in conflict during discourse (Daron et al. 2002, 2007). An epistemically regulated student will engage in conflict to enhance her competence in the discussed topic. In science contexts, epistemic conflict might involve a student questioning his discussant due to different interpretations of evidence. A relationally regulated student, on the other hand, engages in conflict to question the other’s competence. As any educator would expect, epistemic regulation is more likely to promote cooperative learning where students help each other better understand the topic at hand, while relational regulation promotes competitiveness between students in which students assert they have the correct answer or conclusion (Daron et al. 2007). It is not surprising that students who experience conflict as epistemic report a better learning experience than students in relational situations (Daron et al. 2007). In order to create the best environment for learning, instructors should therefore provide instructions to guide students toward epistemic and away from relational regulation by making the goal of the activity better understanding of the topic as opposed to competitive argumentation (Asterhan et al. 2010). In our project, we would like to explore how epistemic versus relational conflicts enable or undermine conceptual development both online and face-to-face. It is plausible that the online environment “lessens the blow” of a relational conflict and enables conceptual development to occur nonetheless, or at least to a greater degree than what would occur if the interaction were face-to-face.

**Discourse Inclusivity**

There is some indication that student characteristics determine the degree to which the students are regulated epistemically or relationally. For example, female students increased conceptual understanding of scientific topics more so than male students
when engaged in a relational conflict (Asterhan et al. 2010). However, a closer look at these data indicated that female students in the relational treatment used more consensually constructed discourse and explanations supported by evidence (Asterhan et al. 2010). In other words, female students became more cooperative, even though the task was set up to be a relational conflict, and their conceptual understanding benefited as a result. It is therefore important to consider the role that gender, and the differential discourse patterns in which males and females may engage, play in establishing epistemic or relational conflict during scientific argumentation. In our project, we plan to explore how these gender-mediated interactions occur both online and face-to-face, as it is plausible that the online environment diminishes the gender effect.

Despite instructors’ best efforts to devise compelling discussion tasks, students’ satisfaction with discussion tasks vary and thus participation in the task is not always to the extent that educators prefer or expect. This situation calls for a consideration of those factors that contribute to students’ satisfaction with discussion tasks, both online and face-to-face. For example, historically marginalized individuals tend to express less satisfaction with group discussions as their ideas and perspectives are often ignored or discounted (Larkey 1996, Grogan & Gusman 2005, Wolf 2011). Previous research has identified inclusiveness and conflict as salient factors in member satisfaction with group experiences (Clark et al. 2000, Jehn 1995). Satisfaction with group work is negatively associated with both relationship and task-focused conflict (Jehn 1995, Jehn et al. 1997). Jehn et al. (2007) note that individual demographic differences (e.g., race and gender) increase relationship conflict, and that informational demographic differences (e.g., education and expertise) increase task-focused conflict. Clark, Anand, and Robinson (2000) suggest that satisfaction with group work is also positively associated with the perception that the member has been given an opportunity to fully participate in all deliberations and that their ideas and perspectives have not been ignored or discounted. Valacich et al. (1992) established means for measuring individuals’ levels of satisfaction with a group task, taking into account the individual’s willingness to work with the group again, the process involved in the group’s task, and the group’s outcome. Understanding how these differ between online and face-to-face learning environments will be informative to devising satisfying tasks that are more likely to compel scientific argumentation. Given that STEM fields are under-represented by several groups (i.e., ethnic minorities and women), students’ perceived inclusivity of their groups is an important factor to consider when using discussions a teaching tool. These issues surrounding individuals’ levels of satisfaction with group tasks online and face-to-face will be explored.

Related to inclusivity, previous studies have found that member diversity has several positive effects on group deliberations (McLeod et al. 1996, Sommers 2006). Groups with diverse memberships generate more and better solutions than their homogeneous counterparts (Kavadias & Sommer 2006), and diversity increases group creativity, flexibility and decision-making quality (Lau & Murningham 1998). However, group diversity also has been linked to reduced cohesion and team commitment, as well as increased polarization, and group conflict (Lau & Murningham 1998). As Horwitz and Horwitz (2007) note, group diversity can be a “double-edged sword,” leading to improved performance and decision quality or to dysfunctional team interaction and suboptimal outcomes.

**Online Discussions**

Computer-mediated communication technologies, such as online discussions, have been found to mitigate social-status inequalities and the associated negative effects in deliberative groups (Kiesler and Sproull 1992, Dubrovsky et al. 1991). Dubrovsky et al. (1991) refer to these phenomena as “the equalization effect.” As a result, members traditionally marginalized in face-to-face group deliberations (such as such as women, people of color and people with disabilities) often prefer online discussions (Chidambaram 1996). Online discussions produce a greater number of ideas than face-to-face discussions because of increased participation and reduced idea production blocking. This results in both a greater number of agreement and disagreement messages as participants feel freer to share their views and to take issue with different perspectives (Chidambaram, 1996). Kramer et al.’s (1997) communication quality scale captures the idea that quality group communication is premised on inclusion. We will use this scale to capture students’ perceived inclusivity of their groups, both online and face-to-face.

A summary of this literature indicates that there are several challenges to engaging students in scientific argumentation that can be either resolved by or exasperated by the use of online discussion boards as a medium through which students engage in scientific argumentation. These challenges include:

1. Establishing classroom norms so that students appropriately frame discussion tasks.
2. Understanding how students’ perceived threat to status affects their ability to engage in productive scientific argumentation.
3. Encouraging epistemic regulation of discourse, which is more likely to support conceptual development.
5. Increasing students’ satisfaction with discussion tasks.
6. Increasing students’ perceived inclusivity of groups within which they are participating.

These challenges frame our objectives of this project, which will be discussed in the next section.

**RESEARCH PLAN**

**Objectives**

Our specific objectives for this project are to address the six challenges summarized above through several empirical investigations that will take place over two years. Each investigation will give rise to teaching implications that will then be applied in two courses toward the end of the project. Objectives of each investigation will be discussed in turn.

1. The objective of the first investigation is to determine to what extent an introductory Socratic dialog with students affects their ability to frame productive scientific argumentation (defined earlier) as behavior appropriate to their science classroom. The Socratic dialog will be implemented both online and face-to-face and elements of productive scientific argumentation will be quantified in the two treatments. This investigation addresses Challenge 1, defined above.

2. The objective of the second investigation is to determine to what extent providing students with discussion tasks that they see as related to their lives affects their ability to employ discourse patterns that they use outside of school and are appropriate to scientific argumentation. Student groups working online or face-to-face will receive discussion tasks that are either anthropocentric (i.e., related to their lives) or biocentric (i.e., related to non-human organisms), and elements of productive scientific argumentation will be quantified in the two treatments. This investigation addresses a different aspect of Challenge 1.

3. The third investigation’s objective is to see to what extent group characteristics influence the scientific argumentation behaviors in which group members engage in both online and face-to-face environments. The specific group characteristics that will be examined are gender and students’ perceived relative status. Therefore, this study addresses Challenges 2 and 4.

4. In the fourth investigation, the objective is to observe the degree of conceptual development that occurs when students engage in epistemic versus relational discourse, both in online and face-to-face contexts. Participants will be paired with an undergraduate member of the research team who will bring on the epistemic or relational conflict either in an online or face-to-face discussion; a brief pre/post-assessment on conceptual understanding of the topic will be used to assess conceptual development. This study addresses Challenge 3.

5. The objective of the fifth investigation is to determine to what extent learning environment (i.e., online or face-to-face) affects student satisfaction with the group discussion exercise. The specific group characteristics that will be examined are students’ satisfaction and learning environment. This study addresses Challenge 5.

6. The objective of the sixth investigation is to determine to what extent learning environment (i.e., online or face-to-face) affects student perceived group inclusiveness. The specific group characteristics that will be examined are students’ perceived group inclusiveness and discussion setting. This study addresses Challenge 6.

Each of the objectives discussed above will be addressed in a separate empirical investigation, the proposed methods for which will be discussed in the next section.

**Data**

Participants for this research will be recruited from Darner’s introductory-level biology course, which has nearly 1000 students (separated into several sections) enrolled every semester. During fall and spring semesters, the course is taught face-to-face and involves group discussion tasks. During the summer semesters, the course is taught online and also involves group discussion tasks. Funding has been sought to provide modest compensation for research participants so that
investigations can take place in a controlled laboratory setting, but if this funding is not provided, the researchers will consider performing the research in situ, as curricular components of the biology course.

For several of our investigations, it will be necessary for us to operationalize “productive scientific argumentation,” as we have defined it. Recall that we claim that productive scientific argumentation has three components: 1. Students engage in all three discourse patterns (i.e., sense-making, articulation of ideas, persuasion) without illogically committing to one over the others, 2. Students take into account evidence (including counter-evidence) in making claims, and 3. Students show indication of conceptual development in the science concepts being discussed. In order to operationalize the first component, transcripts from discussions will be coded to identify the three discourse patterns for each participant, and codes will be enumerated so instances of each pattern from each participant can be compared to each other. In order to operationalize the second component, initial coding of discussion transcripts will identify all those instances in which evidence was provided to support a claim. A secondary round of coding will occur that describes whether or not participants accounted for that evidence in the discourse immediately occurring after the evidence was presented. Dividing the number of these secondary codes by the primary codes will yield a percentage of pieces of evidence that were taken into account during the discourse. The final component of productive scientific discourse will be measuring content knowledge with a brief (1-3 short answer questions) content knowledge assessment administered before and after the discussion task. Answers will be coded using a previously defined rubric.

**Investigation 1**

In order to determine the effect of a Socratic dialog on students’ appropriate framing of discussion tasks, a two-by-two factorial design will be performed in which 36 participants will be divided into four treatments varying according to dialog type (Socratic vs. didactic) and learning environment (online discussion vs. face-to-face). All participants will be given a content knowledge assessment before and after the discussion task. Participants in the Socratic treatment will first engage in an introductory discussion (either online or face-to-face) in which all participants examine transcripts from two fictional discussions. One transcript will exemplify ample epistemic regulation and the sense-making, idea-articulation, and persuasion discourse patterns. The other transcript will contain substantially more relational regulation and discusants in the transcript will utilize either sense-making or persuasion significantly more often than other discourse patterns. After transcript examination, students will be prompted in the Socratic discussion to comment on which transcript demonstrates a productive argument and in which transcript substantial learning occurred. To conclude this discussion, the group of participants in this treatment, facilitated by member of the research team, will devise a short list of discussion guidelines that, under the direction of the facilitator, will direct participants toward epistemic regulation and a balance between the three discourses patterns. In the didactic treatment, a member of the research team will simply present discussion guidelines to participants that exemplify epistemic regulation and a balance between the three discourses patterns. After guideline creation/presentation in both treatments, participants will be divided into groups of three and will engage in identical discussion tasks. The discussion from online treatments will simply be downloaded to a text file, while face-to-face discussions will be video-recorded and transcribed. Transcripts from both treatments will be coded for productive scientific argumentation, as described above. Multiple analyses of variance will be performed to test for significant effects of dialog type and/or learning environment on the three components of productive scientific argumentation.

**Investigation 2**

In order to examine if discussion tasks posed as related to students’ lives (anthropocentric) leads to more productive scientific argumentation than abstract (biocentric) tasks, 36 participants will be arranged into groups of four. Half of these groups will engage in a discussion online, while the other half will engage in face-to-face discussions. Each group will be provided four discussion tasks categorized as anthropocentric epistemic, anthropocentric relational, biocentric epistemic, and biocentric relational. Groups will receive these tasks in a randomized order. As the name indicates, anthropocentric narratives will involve human-based topics that relate to student’s lives and interests. For example, a task about human illness would be classified as anthropocentric. Biocentric tasks will include non-human animals, plants, and bacteria. Again, the discussion from online treatments will simply be downloaded to a text file, while face-to-face discussions will be video-recorded and transcribed. Transcripts from both treatments will be coded for productive scientific argumentation, as described above. Multiple analyses of variance will be performed to test for significant effects of task type and/or learning environment on the three components of productive scientific argumentation.

**Investigation 3**

This investigation study is designed to take into account participants’ content knowledge, gender, and perceived relative status of group members. In order to investigate which group characteristics contribute to productive scientific
argumentation, forty participants will be distributed into one of five types of groups: all-male, all-female, mixed-gender with equal numbers, mixed-gender with more males, and mixed-gender with more females. Each group will be comprised of four participants. There will be one group type in each of the learning environment treatments (online vs. face-to-face). Participants will all be recruited from the same course to increase the likelihood that they know each other. Pre/post-discussion content assessments will be administered on the discussion topic. In order to understand participants’ perceived status relative to their group members, participants will be asked to rank their group members 1-4, 1 being the least competent for science problem-solving and 4 being the most competent for problem solving. A follow-up question will ask participants what factor(s) their ranking was based on. Examples of these choices include: group members’ scientific knowledge, how many Facebook friends group members have, group members’ participation in class, how cool group members seem, etc. All groups will then engage in an identical discussion task. The discussion from online treatments will be downloaded to a text file, while face-to-face discussions will be video-recorded and transcribed. Transcripts from both treatments will be coded for productive scientific argumentation, as described above. Multiple analyses of variance will be performed to test for significant effects of gender composition, perceived relative status, and/or learning environment on the three components of productive scientific argumentation.

Investigation 4

In our fourth study, we will examine the degree to which epistemic regulation during scientific argumentation supports greater conceptual development, as compared to discourse that is regulated relationally. This study will also employ a two-by-two factorial design. Twenty participants will be divided into two treatment groups according to learning environment (online vs. face-to-face), and all participants will be given a content knowledge assessment before and after the discussion task. Half of the participants in each treatment will receive the epistemic treatment, while the other half will receive the relational treatment. The epistemic or relational nature of the treatments will be established in two ways. First, instructions for the discussion task will set the goal of the task as to either come to a consensus (in the epistemic treatment) or convince your partner of your argument (in the relational treatment). Second, all participants will complete the discussion activity with an undergraduate member of our research team. The undergraduate will be trained in how to induce epistemic or relational discourse, and s/he will maintain that regulation type throughout the discussion. A two-way analysis of variance will be used to assess significant effects of learning environment and/or regulation type on changes in conceptual understanding.

Investigation 5

This investigation will examine the degree to which learning environment (i.e., online or face-to-face) affects student satisfaction with Investigations 1-4. All participants in all treatments will complete a post activity questionnaire containing group satisfaction items developed by Valacich et al. (1992). Multiple regression analysis will be used to assess the significant effect of discussion setting on group satisfaction.

Investigation 6

This investigation will examine the degree to which discussion setting (i.e., online or face-to-face) affects student perceptions of group inclusiveness. All participants in all treatments will complete a post activity questionnaire containing inclusiveness items developed by Kramer et al. (1997). Multiple regression analysis will be used to assess the significant effect of discussion setting on perceived group inclusiveness.

CONCLUSION

The community of science education researchers that studies scientific argumentation has demonstrated that there are many challenges to compelling students to not only discuss science topics but also do so in a way that resembles authentic scientific discourse. This matter is complicated by the fact that many science educators are encouraged to transition their courses to online settings where instructors potentially have less ability to monitor the quality of scientific argumentation occurring among students. This project will bridge the intellectual circles of research in scientific argumentation and online learning to increase our collective understanding of how to engage students in scientific argumentation both face-to-face and online.

This research has the potential to give rise to numerous findings that increase the quality of scientific argumentation among students. Findings will be applicable to structuring curricula and teaching actions that establish classroom culture that compel authentic scientific discourse. Dissemination will occur to both the science education and information systems communities, enabling a transformation of online science education.
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REFERENCES


