Differences in Rhetorical and Refutational Argument Complexity by Grade Level

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Abstract: Engaging students in argumentation encourages a productive understanding of scientific knowledge. In order to investigate arguments at different grade levels, we present a comparison of arguments from 7th and 11th grade biology students from similarly structured modeling assessments using an argumentation framework. We note that while students at both levels constructed arguments, differences arose in the kinds of rhetorical statements and refutational strategies. We discuss these differences in conjunction with scaffolding and implications for design.

Background

Argumentation engages students in constructing and critiquing claims about phenomena using appropriate and sufficient evidence (e.g., Krajcik & McNeill, 2012). This, coupled with using more real-world phenomena is a goal of the *Next Generation Science Standards* (NGSS) and policies elsewhere (NGSS Lead States, 2013). This knowledge-building process is one in which arguments develop to make sense of data following peer debate, critique, and revision (e.g., Sampson & Clark, 2008). Scientific argumentation plays a central role in evaluating competing models based on evidence, or identifying the best model or explanation.

Scaffolding and task structure play a major role in the kinds of arguments that students can construct and critique (Krajcik & McNeill, 2012). These arguments tend to contain increasingly robust aspects of arguments (e.g., a rebuttal, more reasons) when explicit scaffolds help students attend to those features of arguments. While we know that students tend to construct increasingly robust arguments as they move through different grade bands particularly with scaffolding (e.g., Kuhn & Udell, 2003) we know less about the nuance between those differences. This paper addresses the impact of scaffolding on student argumentation and evaluate the kinds of complexity and nuance that students display at two grade levels using the same argumentation framework.

Theoretical framework

Argumentation is the process of using data to defend or refute a standpoint (Toulmin, 1958), and is a critical knowledge-building process that appears in science classrooms as a way to support student understanding of science concepts (e.g., Driver, Newton, & Osborne, 2000). Students can be presented with claims that describe scientific phenomena or scientific models that include an underlying mechanism, but students find evaluating competing mechanistic models to be cognitively demanding (e.g., Krist, Schwarz, & Reiser, 2019). Evaluating competing arguments is central to the knowledge-building process, and students can critique and argue about why one argument is better supported by evidence oftentimes by demonstrating that more evidence supports evidence over another. This kind of weighing strategy has been described before (e.g., Nussbaum et al., 2019) as a way of either counting the amount of supporting evidence in support of a chosen argument or by integrating the evidence into the argument or by integrating the evidence into the argument and showing how that evidence relates to the chosen model, either as a warrant or as backing for that chosen model (Cavera, Duncan, & Chinn, 2018). However, we know that students find difficulty in constructing and critiquing competing claims and models of competing phenomena, often developing supporting statements of their chosen claim without discussing a competing idea. We focused on argumentation across two grades in order to understand more about the differences in argumentation across middle and high school. We used the *Integrative Argumentation Framework (IAF)* which focuses on an analysis of complexity and nuance of arguments through the lenses of structural, epistemic, and rhetorical perspectives of arguments (Cavera et al., 2018). We developed an assessment about a topic in biology that aimed to evaluate students' competencies and reasoning with models, and the construction of evidence-based arguments about core science topics. Our research questions are: What are the kinds of arguments that students develop at the middle school and high school levels with a scaffolding suite? What are the types of refutational and rhetorical features found in student arguments?

Methodology

Study context

The study took place in two North Eastern schools—a middle school (7th grade) and a high school (11th grade). Students participated in a modeling-based biology curriculum and provided students with multiple opportunities to develop evidence-based arguments in support of a chosen model. During instruction, students were provided with a scaffolding suite that included: (a) Model Quality Criteria List, a class-generated list to engage in discussions about what qualifies as good models displayed for the duration of instruction (Pluta, Chinn, & Duncan, 2011), and (b) the *Model Evidence Link* (MEL) matrix, a scaffold which had students evaluate both the evidence quality (e.g., scientific accuracy) and the relation of each piece of evidence to each of the provided models (e.g., support, contradict). All data discussed herein comes from the transfer assessment at the close of both curricula.

Instrument design and data collection

Students were provided 60 min. to complete the assesssment. The assessment included five pieces of evidence that varied in quality and two competing explanatory models. The evidence provided to students were either of high quality (e.g., scientific studies), provided information on the phenomenon (e.g., description of the phenomenon), or was an anecdotal account. Once students were presented with all five pieces of evidence and the two explanatory models, they were asked to write an argument that explored which model best explored why muscles hurt 24 to 72 hours after exercise. We report data from students who completed the argument (n = 92 middle school, n = 119 high school). Each assessment was given to students at the end of instruction which was approximately 20 weeks for middle school and 10 weeks for high school.

Analysis

We analyzed student argumentation using the *IAF* (Cavera et al., 2018). This framework divides student arguments into coherent propositions or *argument moves*. These moves are categorized into three major perspectives: *structural*, which captures the presence of a *Claim statement* (e.g., *I believe model A is best*.), and *Support* or *Refute* statements which provide credence (e.g., *I think the model is correct because evidence 1 and 2 support it.*) or demonstrate how a competing model is false (e.g., *The only evidence that supports model B is evidence 4 and that isn't a good piece of evidence*.). *Epistemic* moves are those in which a student appeals to epistemic ideals to satisfy an epistemic aim (e.g., *The model has good pictures. It shows a step-by-step process.*). *Rhetorical* moves include the *Setting the Stage* moves, which are those that provide a strategic organization of the argument. We identified two major types of *Rhetorical* moves: (a) *Overview* moves where students identify differences between models (e.g., *Model B talks about damaged cells which Model A doesn't even mention.)* and (b) *Preview* where they provide a summary or layout of the argument (e.g., *I think [the] lactic acid [model] is better. There are more evidence in support of it, like evidence 1, 2, and 3*.).

We took this framework and expanded the *Refute* move category based on a prior coding scheme (Cavera & Duncan, 2018) in order to capture the kinds of refutational strategies that students applied during their arguments. These include three major refutational strategies: (a) refutation based on congruence with existing theories, (b) refutation based on evidence credibility, or (c) refutation by evaluating the quantity of evidence that supported each model in conjunction with (a) or (b). Three independent coders coded 22% of the MS data and 38% of the HS data. Interrater reliability was 86% and 91%, MS, HS respectively. All disagreements were discussed.

Results

Composition of student arguments at the middle school and high school levels

When comparing arguments (Table 1), middle school students wrote shorter arguments that contained a higher frequency of *Support* moves while containing far less of the other argumentation moves. While students at both grade levels selected the better supported model at approximately the same rate, they did so in different ways.

Table 1: A comparison of arguments at the middle school and high school levels

	Middle School	High School
Model Selection	Model A: 47% Model B*: 48%	Model A: 46% Model B*: 54%
Avg. number of moves	2.8	4.2
Avg. word count	70±15	177±12
Claim	19%	22%

Support Moves	44%	34%
Refute Moves	9%	14%
Epistemic Moves	21%	16%
Setting the Stage	Overview: 3% Preview: 4%	Overview: 9% Preview: 5%

*Model B is better supported by the evidence provided.

Rhetorical strategies

These differences in composition become apparent especially in the *Setting the Stage* and *Epistemic* moves. While some middle school students could provide an *Overview* of their argument, providing a 'roadmap' of their argument: *One reason why I think model A is better is because out of the 5 evidences, [the] majority of them support model A.* Students at the high school level were more likely to provide a more rhetorically complex *Preview* rhetorical move such as: *Overall, we can see that model 1 has more evidence contradicting it than supporting it than model 2. Model 2 has the best pieces of evidence supporting it and more evidence supporting it than model 1 does.* By attuning the reader to rhetorical strategy—discussing each evidence and its relation to each of the models the student is then able to then juxtapose the models again once they have evaluated each of the evidences.

Refutational approaches at the high school and middle school grade levels

Parsing the kinds of refutations that students attended to in their arguments (Table 2) students at the middle school level focused on the *credibility of the competing evidence* as a means of refuting the competing model. Students used this strategy 36% on its own and all but one student used it in conjunction with the *quantity of evidence that supported each model* strategy. When high school students refuted, they often combined strategies in conjunction with the *quantity of evidence that supported each model* with more students focusing on the credibility of evidence.

Table 2: Refutational strategies undertaken by grade level

	Middle School	High School
Credibility of evidence strategy	39%	28%
Congruence with existing theories strategy	23%	24%
Quantity of evidence that supported each model strategy	38% [α]	48% [α]

[α] Represents all students who chose this refutational strategy with either the credibility of evidence strategy and congruence with existing theories strategy.

Each of these refutational strategies is a complex approach to arguing with middle schoolers—often focusing on the *Credibility of evidence* and *Quantity of evidence* to support their idea that several evidences support their chosen model. This, tied with their credibility of the evidence that supports their chosen model, such as in the case: *model A is better because it has a chart explaining before and after exercise meanwhile model B only has pictures that to me don't help the reader* provides a powerful series of refutations. High school students often focused on the same combination of refutational strategies as middle schoolers but discussed the evidentiary relationship between multiple evidences and to the models often focusing on the qualities of evidence, the underlying mechanisms of the models, and the relationship between these moving parts.

Discussion

We presented data from middle school and high school student arguments and have demonstrated that when students are provided scaffolding, they can develop extended arguments that contain rhetorically complex ideas and refutations. Not only do students generate these kinds of arguments at each grade level they attend to different kinds of strategies to refute the competing model.

When considering argument complexity, the appearance of appeals to epistemic ideals, rhetorical ideas, and refutations are evident, both middle school and high school students developed arguments that contained these features. High school students focus on the relationship between the models and evidence, attacking the

connection as compared to middle schoolers who attack qualities of the model and evidence. In each instance students are refuting; however middle schoolers tend to focus on their model quality criteria list and describing how each of the evidence support their own model and not the competing model based on provided scaffolds. This demonstrates the difference in what is important to tackle and differentiate between—the model evidence connection or epistemic qualities.

Students at both levels could argue complexly especially when refuting. Students just need complex tasks that ask for extended evidence-based arguments. The refutations attended to are powerful but the strategies at each level were different with more attention at the high school level paid to the connection between the model-evidence connection while middle schoolers paid more attention to the qualities of the evidence that support their own model. These approaches differ from what Anderson and colleagues (2001) and Nussbaum and colleagues (2019) have previously found. We also know from previous work and others in the field that discussing the communicative features of arguments (e.g., pictures, titles, etc.) are what students' value *before* instruction (Pluta et al., 2011). Even with scaffolding students at the middle school level rely on these communicative features to refute the competing model and its evidence. Students at the high school level begin to tackle that relationship between the model and evidence noting the strength of the model is only as good as the evidence that supports it.

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