When Dissent and Debate Risk Fracturing Mathematics Learning Communities

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Abstract: As U.S. mathematics education focuses on argumentation, reasoning, and critique in learning, this analysis explores children's experiences of mathematical debates. The data draw from a teaching experiment contrasting student-driven (n=25) and teacher-guided inquiry (n=27) with primary school students. In groups, children evaluated data comparing two online search engines to argue which one was "best". In interviews, teacher-guided inquiry groups reported greater discord (personal attack) than student-driven inquiry. Further, teacher-guided inquiry groups were largely unable to recollect the mathematical arguments under debate while their student-driven counterparts could do so with specificity. These outcomes, alongside classroom video analyses of representative debates, demonstrate that when dissent devolves into discord, the value of debate for disciplinary learning can erode. Although debate is often associated with civics or science education, this analysis argues the importance of debate as a site for understanding the disciplinary and relational dimensions of children's experiences of mathematical learning.

Introduction

U.S. mathematics education casts argumentation, reasoning, and critique as essential practices of disciplinary learning (e.g. CCSI, 2010). This analysis explores children's experiences of mathematical debates, as a site where argumentation, reasoning and critique converge. When children debate differing perspectives, reason through them in disciplined ways, and reconcile competing interpretations *without* interpersonal antagonism, such experiences represent, in the immediate sense, a robust learning community; in a more distal sense, they represent the building blocks of a robust democracy. As political scientist McCoy describes, the dangers of adversarial debate devolving into animosity reflects a nonpolarized democracy devolving into a polarized one (McEvers & McCoy, 2017). In nonpolarized democracies, opposing camps understand dissent as consequentially about reconciling ideas among a diversity of people to find solutions. Similarly, engendering a nonpolarized learning community means debating mathematical ideas without engaging in *ad hominem* attacks. In order to design for such ethical spaces of learning, understanding the disciplinary and relational dimensions of how children experience debate, is essential.

These data were collected during a mathematics teaching experiment with primary school students. During the teaching experiment, children either experienced student-driven or teacher-guided inquiry in comparing data from two online search engines. (see Sengupta-Irving & Enyedy, 2015). The children were to reason and justify which online search engine was the best choice based on the data and task parameters. Over five days children deliberated in groups and, on the final day, they rendered their collective final decision. In this analysis, we report on findings that speak to how students describe their experiences of debate, the specificity with which they can recall mathematical ideas under debate, and to what extent differences in students' experiences relate to the pedagogical approach taken.

Prior research

This work sits within broader calls for creating "math-talk" learning communities to promote disciplinary proficiency (Kilpatrick, Swafford & Findell, 2001). In particular, discussion and debate help clarify understanding, provide linguistic tools for expressing ideas, and engage learners in the "primary mechanism" for conceptual understanding (Rumsey & Langrall, 2016). While debate has often been used as a lens of discourse analysis (e.g., Enyedy et al., 2008), our focus on debate itself, and its relationship to peer dynamics, content, and pedagogy, is novel.

Studying peer dynamics, particularly in small group math learning has contributed new knowledge on student agency, authority, enjoyment and the cultivation of mutual respect (Boaler, 2008; Sengupta-Irving, 2014; Sengupta-Irving & Enyedy, 2015). This analysis contributes new knowledge in considering how pedagogy may shape the disciplinary rigor of mathematical debates, and the relational dynamics that govern them.

Methods

Setting and participants

These data were collected at an ethnically diverse California elementary school. Representative of the area's population more generally, the school was 36% White, 32% Latinx, 14% Asian, 10% African American, and 8% Other. Nearly all 5th grade students (n=52 of 54) participated in the study under the instruction of Ms. Parker, who had 15 years math teaching experience.

Procedure

The mathematical task was modeled after research-based data and statistics lessons administered to 7th grade students (Cobb & McClain, 2004). The task required students to analyze various graphical representations of website traffic for two search engines to determine which was better (e.g., a table of values, modal distributions, column graphs). By conventional statistical measures, neither website was better (e.g., measures favored Google and bing evenly), which allowed students to construct arguments and debate them rather than settle an irrefutable "right" answer. Students were assigned by the school to one of two pedagogical approaches: student-driven inquiry (n=25) or teacher-guided inquiry (n=27). In student-driven inquiry, students explored data and invented strategies through discussion and debate. After students produced a solution they learned the formal terms for the ideas (e.g., mean, range) and reached a consensus decision. In teacher-guided inquiry, students were led to explore each representation as the teacher explained key statistics concepts. Students produced a solution, restated the statistical strategies in their words, and debated the outcomes to a final decision. All students took a written pre-posttest based on released items from the National Assessment of Educational Progress (NAEP).

Data collection and previous results

This analysis draws on the results of semi-structured interviews with students and video content logs of their classroom experiences. Semi-structured individual interviews (25-35 minutes) were conducted within one week of the experiment's conclusion. The interviews explored students' experiences, perspectives on peers, statistical concepts, and how a final decision was reached. This analysis also draws on classroom video from groups experiencing extended debate such that at least one person remained in dissent on the final day (~6 hours). These videos contextualized and illustrated students' recollections of ideas under debate and the relational experiences of those debates.

Pevious results (see Sengupta-Irving & Enyedy, 2015) show students in teacher-guided and student-driven inquiry showed statistically significant gains from pre- to post-test ($t=4.8235$, $df = 25$, $p < 0.00001$ and $t = 4.7382$, $df = 26$, $p < 0.00001$, respectively) but neither outperformed the other ($t=0.9162$, 52, 0.364). However, free response surveys reveal children in student-driven inquiry were more positive about their learning experience than their teacher-guided counterparts, as determined by Fisher's Exact Test ($p < 0.05$). Further still, video analyses demonstrated that children in student-driven inquiry were more deeply engaged in mathematical practices, which we contributed to their more positive experience. This analysis explores the latter outcome further by paying analytic attention to the disciplinary and relational dimensions of how students experienced debate in relation to the designed pedagogical contrast.

Data analysis

Student interviews were subject to iterative cycles of descriptive coding (Miles, Huberman & Saldaña, 2013). We coded children's talk of problem solving (*Strategy*); group dynamics and assessments of group members (*Group Dynamics, Peer Assessment*); the nature of deliberations (*Decision Making*), and how the final decision was rendered (*Final Decision*). As Table 1 depicts, parent codes begat child codes to specify and delineate among students' recollections (e.g., *Final Decision Making→Debate→Math-Based→ General*: means the *final decision* involved *debate*, which was reported as determined through *mathematical ideas* that recollected in *general terms*).

Table 1: Examples of two descriptive codes applied to student interviews

Parent Code	Definition	Child Codes	Additional Child Codes
Peer Assessment	Commentary assessing peers	Positive | Negative | Neutral | Unclear	Task-Oriented | Interpersonal | Both
Final Decision	Characterization of final group decision	Debate (Dissent) Math-Based (& No Dissent)	Debate → Majority Rules | Not Using Data | Math-Based (Specific, General, Inaccurate, Tally

		Unclear Not Using Data	Majority, Unclear) Math-Based → Specific | General | Inaccurate | Tally Majority | Unclear

Coding was conducted by two independent researchers working together on five percent (5%) of the data before coding the remaining transcripts, apart. Interrater-reliability was ~87%; discrepancies were resolved through discussion, and as aligned to codebook definitions.

Content analysis of video logs (Derry et al., 2010) were used to delineate which groups reached a consensus final decision with little or no debate from those that engaged in debate throughout. These outcomes were also confirmed by students' interviews. Classroom videos of final deliberations (n=6 hours) were used to contextualize and elaborate students' interview-based recollections and present representative illustrations (though not presented here).

Findings

We report three findings that speak to how students describe their experiences of debate, the specificity with which they can recall mathematical ideas under debate, and to what extent differences in students' experiences relate to the pedagogical approach. First, video content logs (confirmed by interviews) show three of five groups in each pedagogical approach had significant debate with at least one person dissenting on the final day (Figure 1).

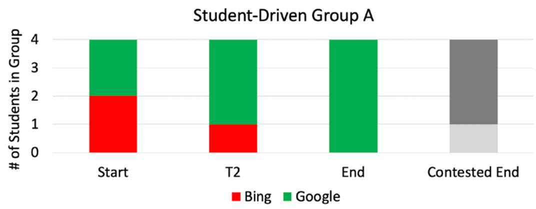

Figure 1. Representation of group trajectory toward final decision.

When asked about the debates, *all but one student* in student-driven inquiry could recall the mathematical ideas with specificity (n=11 of 12). In contrast, *only one student* in teacher-guided inquiry recalled the mathematical ideas under debate with specificity (n=1 of 12). This suggests student-driven inquiry groups were more attuned to the mathematical ideas, even as the presence of debate and dissent across approaches were comparable.

Second, interviews reflect students attuning in different ways to the task, interpersonal dynamics, or their combination, when asked to assess their peers. Table 2 shows over 80% of peer assessments in student-driven inquiry focused exclusively on task-related contributions – e.g., "He was great because he made us talk about range". In contrast, just over half (55.2%) of peer assessments in teacher-driven inquiry focused exclusively on task-related contributions, with nearly one-third (31%) focusing on their combination – e.g., "He was mean and didn't listen to my ideas." This further suggests student-driven inquiry groups experienced debate differently than teacher-guided groups, with the latter being shaped more by interpersonal dynamics.

Table 2: Peer assessment coding distribution by pedagogical approach

	Task	Interpersonal	Both
Student-Driven	82.1%	5.1%	12.8%
Teacher-Guided	55.2%	13.8%	31.0%

Third, when asked about how the final group decision was reached, including how it felt to dissent from the final decision, the affective tenor of students' commentary differed. In student-driven inquiry, dissenting students maintained that their mathematical reasoning was sound but were persuaded without resentment. In contrast, dissenting students in teacher-guided inquiry expressed frustration, fatigue, and resentment at the outcome. In fact, as will be shown with representative video illustrations, *teacher-guided* groups more often devolved into *ad hominem* attack while *student-driven* groups redirected moments of antagonism toward the soundness of mathematical ideas. We infer that student-driven inquiry led groups "back to the math" through shared problem articulation and agency in proposing problem solving strategies which distinguished it from teacher-guided inquiry.

Discussion

When understood as a community of learners (Lave & Wenger, 1991), how students attune to disciplinary ideas and the experiences of peer relationships is of utmost importance to understanding the role of mathematical debate in disciplinary learning more broadly. As seen here, summative assessments suggesting parity of outcome can overlook the emotional and ethical dimension of what it means to learn together. Based on these and prior findings, alongside video representative video illustrations (not presented here), we conjecture a relationship between the pedagogical approach taken toward inquiry (student-driven or teacher-guided) and students' experiences of debate. Specifically, in student-driven inquiry, groups worked together to articulate the problem, interpret data, and propose problem solving strategies. All of which created more robust footholds for engaging competing mathematical ideas while also allowing the emergence of diverse ideas to serve as a lens for assessing peer relations. In contrast, teacher-guided inquiry seemed to constrain students' sense-making by its reliance on teacher guidance, which may explain why discord and fatigue overshadowed children's recollections of mathematical ideas and relationships with others. Indeed, outcomes of affective coding with representative video excerpts of debate (not presented here) make vivid how teacher-driven inquiry supplanted opportunities for students to organize around ideas while those in student-driven inquiry sought new ideas, strategies, and re-interpretations.

Conclusion

These outcomes speak to the importance of considering mathematical debate as a site for understanding the ethical, political, and affective experiences of students in mathematics in relation to peers and the pedagogy; of engendering learning communities where dissent does not devolve into discord. Doing so designs into relief a relationship between students experiencing nonpolarized learning in schools and the social worlds they will someday build far, far beyond the classroom walls.

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