Science
Education

Scientific Argumentation for All? Comparing Teacher Beliefs About Argumentation in High, Mid, and Low Socioeconomic Status Schools

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Received 16 June 2015; accepted 14 October 2015
DOI 10.1002/sce.21214
Published online 29 March 2016 in Wiley Online Library (wileyonlinelibrary.com).

ABSTRACT: Ensuring all students have opportunities to engage in scientific argumentation is a key goal for K–12 students. While research has shown that teachers' beliefs about argumentation can impact their classroom instruction and that students in low socioeconomic status (SES) schools are less likely to experience challenging science learning, there is little research focused on the relationship between teachers' argumentation beliefs and student SES. As such, in this study we explored the scientific argumentation beliefs of teachers in low, mid, and high SES schools. Participants were 34 teachers piloting a curriculum with a focus on scientific argumentation. Our data sources included a survey and interviews. While our analyses suggest that teachers in all types of schools believe argumentation is important, we observed some differences between the teachers of high, mid, and low SES students related to their beliefs about the goals of argumentation discourse and student capability to engage in argumentation. These findings suggest that accountability pressures may impact the beliefs of teachers of low SES students in ways not experienced by teachers of high SES students and offer implications for professional development for such teachers. *Sci Ed* **100:**410–436, 2016

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INTRODUCTION

The recently released Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) call for a change in science education in the United States. While student science learning has traditionally focused solely on the concepts of science, NGSS prioritizes engaging students in scientific practices as an essential aspect of science literacy (Pruitt, 2014). One of these key practices is scientific argumentation. Existing research has identified several factors that may affect teachers' implementation of scientific argumentation in the classroom, including epistemological understandings of science (Newton, Driver, & Osborne, 1999), alternative conceptions about the teaching of scientific argumentation (Osborne, Erduran, & Simon, 2004; Simon, Erduran, & Osborne, 2006), and classroom discourse practices (Alozie, Moje, & Krajcik, 2010; Driver, Newton, & Osborne, 2000; Newton et al., 1999). However, although educational research has shown that teacher beliefs can significantly impact instruction (e.g., Pajares, 1992) there is currently little research focused on teacher beliefs about scientific argumentation (Zohar, 2008).

While one of the goals of engaging students in scientific practices is to increase equity among all students (National Research Council [NRC], 2012), research has demonstrated challenges unique to teachers at low socioeconomic status (SES) schools that influence instruction (Songer, Lee, & Kam, 2002). Likewise, research has found that the beliefs teachers hold about their low SES students can serve as barriers to bringing challenging and cognitively demanding science instruction into the classroom (Calabrese Barton, 2003; Prime & Miranda, 2006). Therefore, to design the most appropriate argumentation teacher education opportunities, we need to consider how student SES may be a factor in teachers' beliefs about argumentation. Consequently, we investigate the following research question: What is the relationship between teachers' beliefs about scientific argumentation and the SES of the students in their schools?

THEORETICAL FRAMEWORK

Scientific Argumentation

Scientific argumentation is an authentic science practice that is increasingly viewed as a key component of science education for K–12 students (NRC, 2012). Research has depicted argumentation as both an important type of knowledge in the science classroom and also as a method of instruction that offers important benefits to students (Tiberghien, 2008). As a disciplinary science practice, argumentation engages students in creating, debating, and critiquing claims and evidence in ways that mirror how scientists make sense of their own findings (Latour & Woolgar, 1986). It is through argumentation that scientists advance knowledge, and, therefore, it should represent a key aspect of students' science learning (Osborne, 2014). Argumentation also supports students in developing the skills to effectively participate in disciplinary literacy practices across content areas (Pearson, Moje, & Greenleaf, 2010) and policy debates rooted in scientific discovery (NRC, 2012; Tiberghien, 2008). The abundance of media coverage about topics such as climate change, GMOs (genetically modified organisms), and fracking underscores the need for all citizens to be able to consider scientific evidence, justify claims, and identify flaws in arguments.

Argumentation also has been shown to be a type of instruction that supports students in meeting other academic goals. A study by Zohar and Nemet (2002) found that students who participated in scientific argumentation during a unit about genetics scored significantly higher on a test of genetics knowledge than students who did not engage in argumentation. Venville and Dawson (2010) also found higher levels of content knowledge for students

doing argumentation. They theorize that participation in argumentation "may have resulted in improvements in the connectedness between isolated facts and concepts resulting in more holistic and insightful knowledge" (Venville & Dawson, 2010, p. 19). Venville and Dawson (2010) also suggest that the motivating nature of debate increases student interest and therefore learning of the content.

In addition to content knowledge, research has found that argumentation enables students to develop more accurate conceptions of the epistemology of science (Kelly, 2008). Students often hold inaccurate perceptions of how scientific knowledge advances and science practices such as argumentation can help students see science as a social enterprise in which knowledge is continually refined or refuted based on new evidence (Sandoval, 2005). Argumentation has also been linked to improved critical thinking skills, communication skills, and reasoning abilities in students (Jiménez–Aleixandre & Erduran, 2008). Perhaps most important, scientific argumentation holds the potential of offering a path for *all* students to participate in science. Authentic scientific practices build on student resources not traditionally appreciated in science learning, such as "individual knowledge, skills, and expertise" (Calabrese Barton & Tan, 2010, p. 32). This means that students can use their everyday discourse skills (Emdin, 2011) to persuade or to question another student or explore and debate problems in their communities. Such opportunities have been shown to increase student interest in science and motivation to learn more (Calabrese Barton, 2003).

In science classrooms, teachers facilitate student engagement in argumentation's production and critique of knowledge through establishing norms of student-to-student dialogical interactions (Zembal-Saul, 2009). These interactions often use a specific structure that reflects the epistemic value science places on the use of evidence to justify claims (Osborne et al., 2004). While there is no consensus in the research community about the components of a scientific argument (Sampson & Clark, 2008; Sandoval & Millwood, 2008), many models are based on Toulmin's (1958) elements of an argument: data, claims, warrants, backings, rebuttals, and qualifiers. The model we use in the research is one that simplifies Toulmin's into three components: claims, evidence, and reasoning (McNeill & Krajcik, 2012). Students can use this argument structure across modalities, to persuasively argue a claim in writing, to gather and critique evidence in text, and to debate with peers (Driver et al., 2000). This type of science learning stands in contrast to traditional methods that focus on teachers transmitting knowledge (Berland & Reiser, 2009; Newton et al., 1999). Instead, students construct and critique knowledge in ways similar to scientists (Driver et al., 2000; Ford, 2008).

While argumentation can hold tremendous benefits for students, it is a challenging instructional strategy for teachers to implement (McNeill & Knight, 2013). One reason for this is that argumentation requires a classroom culture that is markedly different than traditional classrooms (Berland & Reiser, 2009). Instead of a focus on facts and right answers, argumentation necessitates that students persuade (Berland & Reiser, 2009) and critique each other's ideas (Ford, 2008). This puts tremendous demands on the teacher, as they work with students to help them take on new roles in the classroom (Jimenez-Aleixandre & Erduran 2008).

Teacher Beliefs and Argumentation

While few researchers have explored teacher beliefs related to argumentation (Zohar, 2008), studies that have examined this construct have found that teachers can believe scientific argumentation is valuable for students because it encourages critical thinking (Sampson & Blanchard, 2012) and helps students learn content (Sadler, 2006). However, teachers can also believe argumentation is too hard for some students (Sampson & Blanchard, 2012) or

that exposing students to competing arguments will confuse them and cause them to develop misconceptions about science concepts (Osborne et al., 2004; Simon et al., 2006). These types of beliefs can impact the instructional choices teachers make regarding argumentation (Sampson & Blanchard, 2012). Teachers can postpone discussions for extra time (Newton & Newton, 2000; Newton et al., 1999) or continue using teacher-dominated discourse patterns (Alozie et al., 2010). These beliefs can also cause teachers to undermine the goals of argumentation by focusing on "transmitting the information rather than allowing time for the students to study, understand, organize the evidence" (Evagorou & Avraamidou, 2011).

Our decision to focus on teacher beliefs as a factor that may impact scientific argumentation stems from research that shows a "strong relationship between teachers' educational beliefs and their planning, instructional decisions, and classroom practices" (Pajares, 1992, p. 326). We define "beliefs" in this study using Haney, Lumpe, and Czerniak's (2003) definition of beliefs in educational settings as "one's convictions, philosophy, tenets, or opinions about teaching and learning" (p. 367). Although many researchers assert that beliefs and knowledge are in fact the same construct (e.g., Kagan, 1992), we agree with Richardson (2003) that beliefs are different than knowledge because knowledge requires evidence to support its existence while beliefs do not. Understanding teacher beliefs can be an important part of designing effective learning opportunities for teachers (Fetters, Czerniak, Fish, & Shawberry, 2002; Haney, Lumpe, Czerniak, & Egan, 2002). However, while the concept of teacher beliefs has been widely studied (Beck, Czerniak, & Lumpe, 2000; Haney et al., 2003; Nespor, 1987; Pajares, 1992), teacher beliefs related to scientific argumentation are rarely explored (Zohar, 2008). With the adoption of NGSS (NGSS Lead States, 2013) in many states, there will be a tremendous need for teacher education about argumentation along with the other science practices (Reiser, 2013). While research has established elements of effective professional development that can apply to NGSS (Reiser, 2013), a greater understanding of teachers' beliefs about argumentation could provide direction and support for the design and implementation of such experiences for teachers.

Student Socioeconomic Status

We explore teachers' beliefs about argumentation in relation to the SES of students because research demonstrates that student social class can impact teachers' beliefs and instruction in the classroom. Anyon (1980) defines social class as "a series of relationships ... the ways that person relates to the process in society by which goods, services, and culture are produced" (p. 72). These relationships are often reinforced in schools where rote behavior and correct answers are prioritized for lower SES students and creativity and critical thinking for higher SES students (Anyon, 1980). Bowles and Gintis (1976) assert that "the structure of the educational experience is admirably suited to nurturing attitudes and behaviors consonant with participation in the labor force" (p. 9). Therefore, these differential emphases in schools serve to prepare low SES students to take on lower level jobs than students of higher class (Bennett & LeCompte, 1990). In addition, research has shown that cultural practices transmitted by parents to their children can differ by social class (Lareau, 2011). Institutions, such as schools, often value middle class cultural practices more than those of lower class students, and this degree of similarity offers tremendous benefits to middle class students and creates barriers for lower class students (Lareau, 2011).

Research in schools has confirmed many of these findings, demonstrating that students in low SES schools are far less likely to experience challenging science-learning opportunities (Calabrese Barton, 2003) and that low SES schools tend to have more teacher-centered instruction than high SES schools (Peabody, 2005). Teachers at low SES schools may

also experience more pressure than in high SES schools to raise students' standardized test scores (Spillane et al., 2002), and this may increase reliance on scripted instructional programs that focus on memorization (Delpit & White-Bradley, 2003).

In addition, research about teacher beliefs has demonstrated that teachers can hold deficit beliefs of low SES students that impact classroom practice. Prime and Miranda (2006) found that teachers of urban students believed they lacked the "special skills" science requires. As a result of this perceived deficiency, the teachers modified their curriculum to reduce the complexity of the learning. They slowed the pace of instruction, deemphasized some topics, and reduced the depth of coverage for other topics. Song's (2006) study of preservice and in-service teachers also demonstrated this deficit view of low SES students. Gilbert's (1997) study found that preservice teachers believed that a "basic skills" curriculum was most appropriate for urban students. This confirms other findings that students in urban schools can receive less engaging instruction and opportunities to engage with peers (Solomon, Battistich, & Hom, 1996). Haberman (1991) terms this the "pedagogy of poverty" and contends it flourishes at urban schools because teachers believe this type of instruction best serves their students. This line of research suggests that teachers of low SES students may not believe argumentation is appropriate for their students.

Our theoretical framework demonstrates how teacher beliefs in relation to students' social class can impact students' learning opportunities. Furthermore, we argue that research into argumentation and student social class is vital to developing an understanding of how to best design learning opportunities for teachers so all students can engage in this key practice. Therefore, our research seeks to answer the question: What is the relationship between teachers' beliefs about scientific argumentation and the SES of the students in their schools?

METHODS

This study utilized a mixed-methods approach (Creswell, 2003) to explore the argumentation beliefs of teachers in schools with high, mid, and low SES students. The teachers completed a survey consisting of Likert-scale and open-ended items, and a subset of these participants was interviewed about their survey responses. Our goal in utilizing both a survey, which was primarily a quantitative measure, and follow-up interviews, which were qualitative, was to seize upon the advantages of each type of data source. Specifically, utilizing a survey enabled us to determine the beliefs of a larger number of participants across the country, and follow-up interviews allowed us to examine the reasons for teachers' beliefs (Creswell, 2003). Both types of measures can be important in research about beliefs because while surveys often do not fully capture beliefs, their "results can help detect inconsistencies and areas that merit attention" (Pajares, 1992, p. 327) that should be further explored with measures such as interviews. As such, we selected a subset of survey participants who represented a range of beliefs to interview.

Participants

Participants in the study were a purposive sample of 34 public school teachers from across the United States piloting a middle school earth science curriculum during the 2011–2012 school year. Thirty of these participants taught in noncharter public schools and four taught in charter public schools. Using the National Center for Education Statistics' (NCES) definition of a high poverty school as a school in which more than 75% of students enrolled are eligible for free or reduced-price lunch (FRPL) (Aud et al., 2011), we determined that 14 participants taught in low SES schools. We defined schools with fewer than 25% of

TABLE 1
School Demographic Statistics by Region ($N = 34$)

		Geographic Region[a]	
Number of teachers	Northeast (7 Teachers)	Southwest (14 Teachers)	West (13 Teachers)
>75% students eligible for FRPL (low SES)	2	10	2
25–75% students eligible for FRPL (middle SES)	2	4	10
< 25% students eligible for FRPL (high SES)	3	0	1

[a]Southeast and middle west are not included because teachers from these regions did not participate in this study.

TABLE 2
Teacher Demographic Information ($N = 33$)[a]

Type of Teaching Credentials	Multisubject (Elementary)	Single-Subject (Secondary)	Other (e.g., SPED)	None
Number of teachers[b]	15	19	4	0
Highest Level of Education	**Bachelor's Degree (BA, BS)**	**Master's Degree (MA, MS, MEd)**	**Doctorate (PhD, EdD)**	
Number of teachers	16	15	2	

[a]One teacher's demographic information was unavailable.
[b]Does not add up to 33 because teachers could be placed in more than one category if they possessed more than one type of credential.

students eligible for FRPL as high SES schools and schools with 25–75% students eligible for FRPL as mid SES schools. Using the available data about each teacher's school from the NCES and state department of education websites, we determined that 4 teachers taught in high SES schools, 16 in middle SES schools, and 14 in low SES schools (Table 1).

The participants represent a range of backgrounds and teaching experience. Seventeen participants held advanced degrees (masters or doctorate), and all the participants held teaching credentials, with more holding single-subject science credentials than elementary credentials (Table 2).

The participants also represent a range of teaching experience, with the highest number of participants, 12, having 11–15 years of experience teaching (Table 3). While low SES students are more often taught by teachers with fewer years of experience (Jacob, 2007), the range of experience for the teachers of low SES students in our study was similar to the teachers of mid and high SES students.

One clear limitation of our study is that we did not elicit further information about our participants' backgrounds and experiences, such as their racial/ethnic identities or social class. These constructs may have been useful to examine as part of the findings, especially given the focus on student social class in this study.

TABLE 3
Years of Teaching Experience by Student SES ($N = 34$)

	1–5 Years	6–10 Years	11–15 Years	16–20 Years	>20 Years
Number of teachers of high SES students	1	0	2	1	0
Number of teachers of mid SES students	4	3	5	1	3
Number of teachers of low SES students	4	2	5	2	0
Total number of teachers	9	5	12	4	3

Context of Study

The participants piloted between one and three of the following units from the earth science curriculum: *scales and models in earth and space science*, *plate tectonics*, *rock formations*, *currents and earth's climate*, and *space and gravity*. Teachers of high SES students taught on average 1.5 units, teachers of mid SES students 1.8 units, and teachers of low SES students 1.4 units. Each unit included approximately 30 sessions and contained lessons that focused on aspects of scientific argumentation. Participants attended a 1-day professional development session prior to beginning the curriculum that included an introduction to the pedagogical approach, overview of the units to be taught, and training on using the teacher's guide. Approximately 30 minutes of the 6 hours were focused on argumentation. The data for this study was collected after the participants attended the professional development and enacted the curriculum.

The curriculum described the scientific argumentation goals for students as follows:

> Engage in scientific argumentation by identifying claims and evidence in a written argument; knowing that a scientific argument includes a claim, evidence, and reasoning; identifying excellent evidence that supports a claim; supporting claims with evidence and reasoning in discussions; examining two competing arguments to determine which is better supported with evidence; building on others' claims by offering additional evidence in discussions; bringing together evidence from multiple sources to make and support a claim; and writing an argument that has a claim and evidence.

The curriculum also utilized a multimodal approach to science instruction in which students: do-it, talk-it, read-it, and write-it (Pearson et al., 2010). As such, the argumentation lessons cut across modalities with lessons that focused, for example, on analyzing a written argument, and engaging in a science seminar to debate the strengths of different claims.

Data Sources

Two data sources were collected: surveys of all 34 teachers' beliefs about scientific argumentation and phone interviews with 20 of the 34 survey participants. To create the survey and interview items, we conducted a review of the literature to determine possible influences on teachers' instruction of argumentation in the classroom. We identified 19 categories of influences, some of which focused specifically on argumentation, such as beliefs about the teaching of argumentation (Osborne et al., 2004; Simon et al., 2006),

TABLE 4
Six Belief Categories

Belief	Definition
The role of argumentation in the classroom	Teachers' beliefs about the role of argumentation in learning science broadly, covering the importance of the various components of argumentation (i.e., claim, evidence, reasoning).
Classroom discussion practices	Teachers' beliefs about classroom discussion, especially the roles of teachers and students in discussion, including how argumentation is orally communicated between students as peers and between students and their teacher, and the depth of argumentation discussion.
Teacher self-efficacy	Teachers' beliefs about their confidence to teach argumentation.
Using argumentation to accomplish other educational goals	Teachers' beliefs about how they can use argumentation to accomplish other educational goals (e.g., literacy, critical thinking, content knowledge, scientific practices).
Student ability	Teachers' beliefs about their students' abilities to engage in argumentation.
Standards	Teachers' beliefs about the alignment of argumentation to state and national standard and the role of argumentation in student performance on high stakes assessments.
Environment	Teachers' beliefs about how support from administration and teacher-peers, school demographics, and school/district resources affect teachers' capacities to engage in argumentation instruction.

and others that were more general, such as beliefs about the epistemology of science (Newton et al., 1999). We then met with our advisory board to discuss the categories for the instrument development. Our advisors were experts in science education who all held doctorates in their fields. Each advisor was asked to select the factors that were most important for argumentation instruction. Using their feedback, we prioritized categories that referred to key aspects of argumentation, such as beliefs about discourse practices (Alozie et al., 2010; Berland & Reiser, 2009; Driver et al., 2000), and also combined several similar categories into one. For example, we created one category called "environment" for teacher beliefs about argumentation instruction as related to support from administrators, teacher colleagues, and district personnel. This revision process resulted in six categories of teacher beliefs related to scientific argumentation: the role of argumentation in the classroom, classroom discussion practices, self-efficacy, the uses of argumentation to accomplish other educational goals, students' abilities to engage in argumentation, standards, and environment (Table 4).

For each belief category, we developed eight or nine Likert scale or multiple-choice items and one open-ended item for the survey (Table 5). For four of the survey items focused on teachers' beliefs about students' argumentation abilities, we wrote Likert scale items that described fictional students, each of whom represented a type of student that research indicated teachers might possess deficit beliefs about. One example is "Abby" who is a low

TABLE 5
Sample Survey Items

Belief Category	Sample Likert-Scale Items	Sample Open-Ended Items
Using argumentation to accomplish other educational goals	Argumentation is an effective way to develop students' critical thinking skills.[a]	Besides science content knowledge, what other educational goals can argumentation help students achieve? Why?
Student ability	Abby has attended multiple schools in the past few years, as her family has had to move into different living situations. Abby says she participated a lot in science classes in her previous schools. She receives free breakfast and lunch at school every day.[b]	What qualities, abilities, experiences, and/or knowledge do you believe are important for a student to possess to be successful at doing scientific argumentation? Why?
Standards	Argumentation is an important part of my state's science standards.[a]	Do you believe that engaging your students in scientific argumentation will impact their performance on state assessments? Why?

[a]Teachers' choices: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree.
[b]Teachers' choices: 1 = not capable, 2 = somewhat capable, 3 = capable, 4 = very capable.

SES student (Table 5). For the phone interviews, we designed a protocol that included one or two open-ended questions for each of the belief categories (see the Appendix). Two of these questions asked teachers to further clarify their responses on the survey. The phone interviews took between 20 and 30 minutes to complete and were audio recorded and then transcribed for analysis.

Data Analysis

The first author coded the interviews and open-ended survey items using a constant-comparative method (Glaser & Strauss, 1967) to allow themes to emerge that were "close to the data" (Glaser, 1965, p. 437). After identifying the emergent themes, the first author compared the themes for teachers in high, mid, and low SES schools to determine similarities and differences by school type. The second author then independently coded using the same method, and the authors discussed the emergent themes and resolved differences through discussion. These discussions entailed an opportunity for each author to explain her rationale for her codes and identify the evidence from the open-ended survey responses or interview transcripts to support her findings. Both data sources were considered equally in this process, although by their nature, the interview transcripts provided richer data than the open-ended survey items. The authors then discussed whether the evidence supported the proposed codes and whether there were in fact areas of agreement between the authors' codes that necessitated a more nuanced code. This process resulted in the creation of three themes from the qualitative data, which are discussed below. During this coding, both authors wrote memos to ensure an accurate record of the emerging themes and note the

TABLE 6
Belief Factors

Belief Factor	Cronbach's Alpha
Standards and tests	.898
Value of argumentation	.876
Student background and ability	.787
Self-efficacy	.902

connections or contradictions between themes. As Charmaz (1999) suggests, memo writing can help "avoid forcing data into extant theories" and "develop fresh ideas, create concepts, and find novel relationships" in the data (p. 376). The authors also sought disconfirming evidence, which they used to question and revise the emerging themes (Creswell & Miller, 2000).

For the quantitative survey data, we used principal component factor analysis using Varimax rotation to combine the Likert scale items on the survey into constructs to increase the reliability and to create more manageable constructs. This analysis resulted in four belief factors each with a Cronbach's alpha greater than .7: standards and tests, value of argumentation, student background and ability, and self-efficacy (Table 6). We created each factor by summing the individual items and dividing by the total number of items. Dividing by the total number of items allowed the factors to maintain the same scale (i.e., 1 = strongly disagree to 4 = strongly agree), which increased the ease of interpretation.

While our factor analysis yielded four factors, when we analyzed the interview transcripts we saw that teachers tended to discuss the first three factors throughout their interviews. The fourth factor, self-efficacy, was only discussed as an answer to a specific question about confidence to teach argumentation. In addition, as we will discuss next, self-efficacy did not appear as a theme in our coding, whereas the other three factors did. For this reason, we choose to focus on these first three factors in our results and analysis.

For each of these three factors, we conducted an analysis of variance (ANOVA) to determine whether teacher beliefs varied by student SES, with the student SES as the fixed factor and the factor belief score as the outcome variable. We then conducted post hoc Tukey tests for any significant outcomes to determine which groups were statistically different from each other.

RESULTS

Our analysis of the interviews and open-ended survey items yielded three themes (Table 7) that corresponded to the factors from our quantitative analysis: (1) Teachers believe argumentation is valuable, but teachers of low SES students see different benefits than teachers of high and mid SES students related to discourse; (2) all teachers hold varied beliefs about both students' capabilities to engage in argumentation and their role in supporting students in argumentation, and (3) teachers of low SES students believe pressure from standards and state tests can impact their argumentation instruction, whereas teachers of high SES students experience less of an influence.

To further explore each factor, we conducted three ANOVAs (Table 8). The school type was significant in only one factor, standards and tests, $F\ (2, 31) = 3.398$, $p < .05$, which corresponds to our third theme. We ran a post hoc Tukey test to compare each pair of schools

TABLE 7
Emergent Themes

Theme	Representative Quotes (Teacher, SES)
Theme 1: Teachers believe argumentation is valuable with teachers of low SES students seeing different benefits than teachers of high and mid SES students	"Argumentation helped me and made an impact in teaching science because there are some students, or most of the students . . . they really wanted to talk." (Ms. McCarthy, low SES students) "[T]he students are building off what one another are saying, or they're questioning what one another are saying about the same discussion it keeps us on task, and it helps to develop more fully whatever the question is that's being asked to begin with." (Ms. Winters, mid SES students)
Teachers can hold varied beliefs about both student capability to engage in argumentation and the teacher's role in supporting students in argumentation.	". . . they're lacking some of the basic skills of critical thinking. They're not willing to push themselves, the motivation level is very low. Once again, it goes back to their environment and support" (Ms. Rollings, low SES students). "So all students can do it no matter what their background is. Even students who don't have a strong science background could still do, could still engage in argumentation" (Mr. Eldridge, mid SES students).
Teachers in low SES schools believe pressure from standards and state tests can impact their argumentation instruction, while teachers from high SES schools experience less of an influence.	"[A]rgumentation will only have an impact on test scores if a teacher is unable to teach the science content that will be on the test" (Mr. Dale, high SES students). "If they are used to defending their ideas and questioning bad claims, they will be able to pick out the answer choices that are likely to be wrong" (Ms. Ross, low SES students).

TABLE 8
Means and Standard Deviations for Factors by SES

Factor	High SES	Mid SES	Low SES
Value of argumentation[a]	3.64 (0.43)	3.71 (0.31)	3.55 (0.41)
Student background and ability[b]	2.88 (0.60)	3.37 (0.44)	3.33 (0.51)
Standards and tests[a]	1.68 (0.79)*	2.44 (0.58)	2.54 (0.56)*

*$p < .05$.
[a]Teachers' choices: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree.
[b]Teachers' choices: 1 = not capable, 2 = somewhat capable, 3 = capable, 4 = very capable.

to determine where the significant difference occurred. There was a significant difference between the beliefs of teachers in low SES schools compared to those in high SES schools with teachers from low SES schools reporting that their standards and state tests had more of an influence on their argumentation instruction.

We next describe the results of our analyses for each theme along with the corresponding factor. In our Discussion section, we will consider the possible reasons for similarities and differences between teachers of high, mid, and low SES students, and the implications of these beliefs for supporting all teachers in argumentation.

Theme 1: Teachers Believe Argumentation Is Valuable With Teachers of Low SES Students Seeing Different Benefits Than Teachers of High and Mid SES Students

In their interviews and open-ended survey items, teachers of high, mid, and low SES students believed scientific argumentation was valuable for their students. This finding stands in contrast to research that suggests that teachers of low SES students can believe that this type of learning is inappropriate for their students (e.g., Prime & Miranda, 2006). Teachers of all three types of students explained that argumentation is different than typical science learning, which they characterized as focused on memorization and vocabulary development.

Differences between teachers of low SES students and teachers of high and mid SES students did emerge, however, related to the benefits of argumentation discourse. Teachers of high and mid SES students discussed the ways that argumentation engages students to talk to each other and listen to peers' ideas. Several teachers characterized argumentation as a way for students to disagree with other students and defend their ideas. Ms. Marks described a debate in her classroom about the rain shadow effect in which some of the students "came from one direction and then they heard everyone else's side." She stated that the students' disagreements pushed them to consider whether they fully understood the rain shadow effect. Ms. Elms, a teacher of mid SES students, mentioned in her interview that her administrators appreciate her inclusion of argumentation in her instruction because "instead of just saying okay, okay, this is the way it is, memorize this fact and this fact, they like the idea that students are discussing these ideas." Mr. Dale, a teacher of high SES students, explained that argumentation provided a way to support his students in having a productive discussion, not just presenting their ideas. In his interview, he said that argumentation was useful in "helping the students realize that we're not going to just take one disconnected idea after another. We're trying to build something together here." Teachers of high and mid SES students, such as Ms. Marks, Mr. Dale, and Ms. Elms, described a key difference between typical science instruction and science learning that focuses on the practices of science: student discourse. Research has shown that classroom discussions often follow an initiate–respond–evaluate pattern (IRE) (Alozie et al., 2010; Mehan, 1979) where the teacher asks a question, a student responds to the teacher, and then the teacher evaluates the student's response. There is little if any student-to-student talk. Therefore, students are not building on or critiquing each other's ideas, an important feature of scientific practices such as argumentation. While we cannot conclude that teachers of high and mid SES students were able to move away from typical IRE discourse patterns, the comments of these teachers indicate that they believe it is important for students to talk to each other and build on each other's ideas.

Teachers of low SES students also discussed the importance of students talking in class, and the ways argumentation allowed this to happen. However, unlike teachers of high and mid SES students who saw argumentation as a way to engage students in talking to each other, teachers of low SES students focused on argumentation as an enjoyable way to increase students' oral participation in class. Ms. McCarthy stated in her interview that argumentation provides her students "the chance to talk, which they wanted." Ms. Bryant commented that her students are "not used to articulating either verbally or in a written

manner why they think what they think. They're not used to doing that." These teachers of low SES students believe argumentation is valuable because it provides the time and space for student talk, which may be absent from the rest of students' school experiences. However, a few teachers of low SES students discussed argumentation as more than simply speaking more often in class. For example, Mr. Jones stated in his interview, "it's important not only to develop those interpersonal skills but also to have them kind of defend and back up their opinion and question each other." Likewise, Ms. Knight wrote in her survey that she prefers students talk to each other and "build off each other without me calling on them." These descriptions of moving beyond simply talking, toward student-to-student discourse, are more similar to the teachers of high and mid SES students than the rest of the teachers of low SES students. Consequently, some of the teachers of low SES students did value this type of interaction; however, others focused more on presenting ideas.

In discussing student talk, teachers of low SES students also described the challenges they believe their students face in engaging in talk in the classroom. For example, Ms. Knight stated in her interview that she had to work hard to help students learn essential vocabulary to use in their arguments "so that the argument sounded more intelligent ... you want to sound smart when you go out in public and try and talk about things with people." Ms. Green similarly mentioned that "a lot of kids will just come up with some half sentence and then they don't use proper, like, vocabulary or any key words that we've been working on." This suggests that some teachers of low SES students may hold deficit views of their students' discourse abilities.

Our quantitative analysis aligns with the qualitative findings: Teachers in high, mid, and low SES schools were on average between "agree" and "strongly agree" that scientific argumentation is an important part of students' science learning. This factor was measured on the survey by asking teachers to "strongly agree," "agree," "disagree," or "strongly disagree" with various statements related to scientific argumentation (Table 4). Teachers of mid SES students were the highest, at 3.71, between "agree" and "strongly agree" and teachers of low SES students were the lowest, at 3.55, also between "agree" and "strongly agree" (Table 6). Yet, there is no statistically significant difference between the beliefs of teachers of high, mid, and low SES students about the value of argumentation for their students. This is not surprising given that all teachers discussed in their interviews and open-ended survey responses that they believe argumentation is beneficial for their students. The qualitative data, however, demonstrated an important nuance in the beliefs of teachers of low SES that the survey was not able to assess. Specifically, such teachers hold different beliefs about why argumentation discourse is important compared to the teachers of mid and high SES students. We may have not seen a statistically significance difference in the survey data because we were assessing whether teachers believe argumentation is beneficial, but not why they believe it is beneficial, which was one goal of conducting the interviews.

Theme 2: Teachers Can Hold Varied Beliefs About Student Capability to Engage in Argumentation and the Teacher's Role in Supporting Students in Argumentation

The second theme that emerged from our analysis is that teachers can hold varied beliefs of both their students' capabilities to engage in argumentation and their role in supporting students in argumentation. As this theme consists of two subcomponents, beliefs about student capability and beliefs about the teacher's role, we discuss these ideas separately.

Beliefs About Student Capability. As the quotes in Table 7 demonstrate, we had teachers who believed that all students are capable of engaging in argumentation, and teachers who believed that some types of students are less capable. The students most often discussed as less capable were struggling readers, English language learners (ELLs), special education (SPED) students, and low SES students. For example, Mr. Dale, a teacher in a high SES school stated that his SPED and ELL students only think at a "literal" level and therefore cannot participate in argumentation as well as other students. Ms. Rollings, a teacher in a low SES school stated that her students' "social, the economic background" matter because many of these students are "lacking some of the basic skills of critical thinking" as well as "basic skills" to engage in argumentation.

Teachers who discussed all types of students as equally capable of engaging in argumentation also sometimes mentioned these types of students, or specific skills or abilities that might benefit students engaging in argumentation. However, they also stated that all students could be equally successful with argumentation. For example, Mr. Eldridge, a teacher from a mid SES school, wrote in his survey that "the ability to listen, comprehend, and evaluate what another student is saying" is helpful for students to possess, but stated in his interview that "all students can do it no matter what their background is. Even students who don't have a strong science background could still do, could still engage in argumentation." Likewise, Ms. Howard, a teacher in a mid SES school, stated in her interview that in her classroom, "there's a wide variety, there's a huge mix of ethnicity as well as socioeconomic position, but I found no matter . . . ." These teachers understand what skills are helpful for argumentation, but do not view specific traits or backgrounds as impacting students' potential with argumentation.

Interestingly, we had many teachers who expressed *both* types of beliefs, contradicting themselves in their survey responses and/or interviews. These teachers described some students (e.g., ELLs, SPED) as being less capable, but also made statements that all students are capable of engaging in argumentation. These teachers most often stated that all students are capable of engaging in argumentation in response to our interview question about why they indicated on their survey that "Abby," a fictional student who was of low SES, was "capable" or "very capable" to engage in argumentation (Table 5). For example, Ms. White, a teacher from a mid SES school, stated, "I think anybody can participate and can be successful at scientific argumentation no matter where they come from" when asked to explain her choice on the survey that Abby is "very capable" to engage in argumentation. Mr. Grant, a teacher from a high SES school, stated, "anybody can engage in scientific argumentation" to explain his survey response that Abby is "capable" of engaging in argumentation. However, these teachers also expressed beliefs that some types of students are less capable of engaging in argumentation. This most often occurred in response to our interview question about the drawbacks of argumentation and/or the ways students' backgrounds and abilities impact argumentation instruction (see the Appendix). Interestingly, these were both questions we asked before the "Abby" question. Ms. White, for example, when asked to discuss the ways students' backgrounds and abilities impact her argumentation instruction answered, "some kids come with a whole lot and some kids come with nothing." She went on to explain that her students who are "low," struggling readers and ELL students, are less capable of engaging in argumentation. Similarly, Mr. Grant discussed several types of students as being less likely to be successful with argumentation, specifically students who read below grade-level, ELL students, and "kids who don't have as much schema in their background maybe because of the, they are poor, or they are minority . . . they don't have the background knowledge." While these contradictory beliefs could mean that these teachers recognize that it can be more challenging to engage some students, such as those who lack English proficiency, in argumentation, we do not

feel that is always the case. As we will discuss in the second part of this theme, beliefs about the teacher's role, these "contradictory" teachers often expressed lower expectations for the types of students they described as less capable. Therefore, these teachers do not seem to believe that argumentation is simply more difficult for some types of students, but that some students are less capable to engage in it.

One possible reason we observed some contradictory beliefs is that teachers may have identified qualities in the fictional students we described in the survey that mitigated their deficit beliefs of these students' backgrounds. In the interview, we asked about one of these fictional students, Abby, who receives free or reduced lunch. While some teachers expressed deficit views of low SES students earlier in their interviews, when asked about "Abby," they identified qualities in her that they believed could make her successful in argumentation. For example, Ms. McCarthy, a teacher in a low SES school who contradicted herself in similar ways as Mr. Grant and Ms. White, explained that Abby is capable because Abby had been in many schools and "from Abby's experience of meeting different kinds of people he or she can learn a lot of things from the people that she met." Other teachers explained that since Abby participates a lot in school, she must be willing to engage in argumentation. Ms. Marks, a teacher from a mid SES school stated "I think that's probably one of the biggest things, the willingness to participate, if a student, and it sounds like that student is very willing and she enjoyed science in the past." Teachers also mentioned that they have taught students similar to Abby, and these students have been successful. Teachers may have identified redeeming qualities in our descriptions of the fictional students and seized upon either these qualities or their experiences with a similar student to justify their beliefs that Abby is capable, despite expressing deficit beliefs about some types of students.

As previously mentioned, the types of students that teachers with deficit and contradictory beliefs identified most often as less capable to engage in argumentation were low readers, low SES students, ELL students, and SPED students. For teachers of low SES students, however, another type of student also emerged: students who lack specific types of experiences at home. For example, Ms. Knight commented in her interview, "most of my group are Hispanic kids, my school is like almost all free and reduced lunch. I mean, a lot of the kids never leave the neighborhood, they don't have the world experiences" to be successful with argumentation. Ms. McCarthy articulated a similar idea in her interview stating that "home is our first school. So if the student has no support from home, that's also going to affect his or her ability." Ms. Rollings also commented in her interview that she believes the lack of support at home really impacted students' effort "because when there's no support [at home] they're not going to put more effort into the classroom." She tied this to what she believed was her students' inability to think critically stating, "they're lacking some of the basic skills of critical thinking. They're not willing to push themselves; the motivation level is very low. Once again, it goes back to their environment and support." Teachers also related home environment to their belief that the lack of "academic" language at home impacts students' abilities to engage in argumentation. Ms. Shaw discussed in her interview her belief that home environment contributes to her students' lack of curiosity. "[I]t takes a little bit longer to stimulate their curiosity or they don't necessarily come, some obviously do, because the families provide, you know, more exposure to things besides television, and all that stuff." Teachers from low SES schools, despite indicating on the survey that "Abby," a low SES student, was capable to engage in argumentation, also saw their low SES students as lacking the appropriate home experiences to be successful with argumentation.

Beliefs About the Teacher's Role. Despite these varied beliefs about student capability, most teachers explained their role as one in which they are responsible for supporting students to engage in argumentation. However, for many teachers, this responsibility seemed in tension with their deficit or contradictory beliefs that some types of students are likely to be less successful with argumentation. For example, Ms. Jeffs, a teacher in a low SES school who had contradictory beliefs and stated that all students can do argumentation but that SPED students need argumentation "lowered," said that in her classroom she has her SPED students "instead of addressing it from a, I would say a higher order thinking for them, I just asked them to give me a basic" answer. This occurred for many of our teachers, who seemed to view "support" as enabling students to participate in argumentation, but not necessarily with the same goals as other students. Likewise, many teachers used the term "scaffold," but in defining this term did not describe ways to enable their struggling students to engage in the same ways as the rest of their students. For example, Ms. Parks stated in her survey that her students with individualized education plans (IEPs) need more support and therefore it is important to scaffold. Yet, she then stated that she has her higher level students "evaluate, analyze, differentiate and propose" whereas she expects students with IEPs to "recall, describe, or identify." Mr. Dale, who expressed deficit views of his SPED and ELL students, explained that it is important to scaffold for such students, but then also described lowered expectations for argumentation. While some of our teachers were vague about what "support" or "scaffold" might mean, teachers who held either deficit or contradictory beliefs and did define these terms seemed to believe that supporting students to engage in argumentation is important, but not necessarily in ways that enable all students to participate in argumentation at the same high level. Instead, they appeared to lower their expectations or goals for these students in relation to argumentation.

In contrast, teachers who believed all students are capable of engaging in argumentation often used the terms "scaffolding" and "supporting" to explain why all students *are* capable. For example, Ms. Stein stated in her survey, "I don't think students need to possess particular abilities. I do feel like this is a skill that needs to be appropriately scaffolded in order for students to be successful. I have seen students in second grade effectively engage in argumentation as it was well scaffolded." For these teachers, scaffolding enables all students to participate in argumentation in the same ways. This is very different than the teachers with deficit and contradictory views.

Our quantitative analysis yielded no statistically significant difference between the beliefs of teachers in low, mid, and high SES schools related to the capabilities of students to engage in scientific argumentation (Table 6). As previously mentioned, this factor was measured on the survey by asking teachers to classify fictional students as not capable, somewhat capable, capable, or very capable to engage in scientific argumentation (Table 5). The mean score for all teachers was around 3.00, "capable," with teachers from low SES schools at 3.33, teachers from mid SES schools at 3.37, and teachers from high SES schools at 2.88. These quantitative results clearly present an incomplete picture of teacher beliefs as compared to our qualitative analysis. The difference between the quantitative and qualitative results may be the result of utilizing vignettes of fictional students to assess teacher beliefs of student capability to engage in argumentation. Each vignette described a student with a specific profile, such as Abby (Table 5) who is a low SES student. However, each vignette also contained positive qualities for each student, such as Abby's frequent participation in science class. Teachers' ratings may have been inflated if they believed one or more positive qualities mitigated other factors. Utilizing such vignettes to assess beliefs should be the focus of future research.

Theme 3: Teachers From Low SES Schools Believe Pressure From Standards and State Tests Can Impact Their Argumentation Instruction, While Teachers From High SES Schools Experience Less of an Influence

While our group of teachers from high SES schools is a small sample, in their interviews and survey responses, all of these teachers described state assessments and district policies as having minimal impact on their argumentation instruction. Mr. Dale stated in his survey that "argumentation will only have an impact on test scores if a teacher is unable to teach the science content that will be on the test. The test is not set up for critical thinking, but rather for concept-fact based understanding." While state standards and tests might not impact their argumentation instruction, the teachers of high SES students did describe standards and assessments as being prioritized by their school districts. Mr. Grant said in his interview, "there was a lot of pressure from my administration to make sure I address all of the standards which I was not ... I didn't even get to finish the curriculum because of the state standards." While the teachers stated that their argumentation instruction is not impacted by standards and tests, at least for Mr. Grant, these policies in fact shortened the amount of time on argumentation. However, while student performance on a primarily content-based assessment is of great importance in these schools, these teachers do not believe argumentation either aligns with this focus or is impacted by it.

Teachers of mid SES students more often expressed that argumentation aligns with state standards and tests, especially as it relates to content learning. Several of these teachers discussed that administrators supported their instruction of argumentation, even if it did not fit into the district pacing guide, because students learn more content in this way. Other teachers stated that argumentation aligns with various English Language Arts (ELA) standards, such as writing persuasive essays and speaking skills, or will align with the then-forthcoming Common Core State Standards (National Governors Association for Best Practices & Council of Chief State School Officers, 2010). While there are many ways that persuasive writing, for example, and scientific argumentation are similar and mutually reinforcing (Pearson et al., 2010), some teachers of mid SES students expressed varied conceptions about argumentation when discussing such an alignment. One teacher described argumentation as annotating texts. Ms. Bryant defined argumentation in her interview as "having to justify your answer, why you answered something the way you answered it." In addition, several teachers of mid SES students expressed the belief that argumentation supports student test-taking skills such as "how to use diagrams and read data" and the belief that "students will read questions more carefully as they have learned how to consider information they read." While argumentation can align with these goals, it is also possible that teachers do not fully understand the cognitive demand and complexity inherent in argumentation. These beliefs could also emanate from pressure these teachers experience to align instruction with standards and state assessments. These teachers may be searching for a way to accomplish the goals of argumentation and simultaneously impact test scores.

Teachers of low SES students described their teaching as driven by standards and the need to ensure students perform well on state tests. They discussed the greatest pressure from these forces compared to teachers of mid and high SES students. Some of these teachers connected this perceived pressure to their argumentation instruction. Ms. Boyle stated in her interview that typically "if it's not tested on the [state test] we don't basically really teach it," indicating a possible reluctance to include argumentation in her instruction if it is not tested on the state test. Likewise, some teachers of low SES students described not having enough time to do argumentation and review the content for the state test. Mr.

Jones piloted this curriculum with an elective he taught because "I didn't have time just with the state standards to put it into my regular 6 periods of science." He remarked "there's a lot of pressure on you from the high stakes assessment at the end of the year," a sentiment expressed by several teachers of low SES students.

Some teachers of low SES students were also similar to teachers of mid SES students in believing argumentation aligns with other goals, especially test-taking skills. For example, some teachers of low SES students believed there is an alignment between engaging in argumentation and picking correct answers on multiple-choice tests. Ms. Ross wrote in her survey, "If they are used to defending their ideas and questioning bad claims, they will be able to pick out the answer choices that are likely to be wrong." Ms. Jordan wrote in her survey that argumentation would help "students consider all the answers but select the one that has the concrete evidence to support it." These test-taking benefits could result from student engagement in argumentation, but it is also possible that similar to the teachers of mid SES students, these teachers do not fully understand the goals and instruction of argumentation. Likewise, they may be trying to manage pressure to have students perform well on state assessments.

While school type was not significant for the other two factors for the survey, it was for the role of standards and tests, $F\ (2, 31) = 3.398$, $p < .05$. We ran a post hoc Tukey test to compare each pair of schools to determine where the significant difference occurred. There was a significant difference between the beliefs of the teachers of low SES students compared to those of high SES students, with teachers of low SES students reporting that their school and district policies related to standards and tests had more of an influence on their argumentation instruction (Table 8). The teachers of high SES students had an overall mean of 1.68 with a standard deviation of 0.79 for questions related to how much policies, such as high-stakes assessments and state standards, impact their argumentation instruction. On average, these teachers are between "strongly disagree" and "disagree" that these policies impact the instructional decisions they make about argumentation. Teachers of low SES students, however, were between "disagree" and "agree" that their instruction is influenced by standards and tests, with a mean of 2.54 and a standard deviation of 0.56. This aligns with our qualitative analysis that teachers of high SES students do not believe standards and assessments have much influence on their argumentation instruction, whereas teachers of low SES students perceive a greater impact of such policies.

DISCUSSION

Our research suggests three major themes in relation to teachers' beliefs about scientific argumentation. First, teachers from all schools saw argumentation as valuable for students; however, teachers of low SES students saw different benefits of argumentation than teachers of high and mid SES students. Second, teachers held varied beliefs about student capability to engage in argumentation as well as had varied beliefs about their roles and expectations for students. Teachers from all school types with deficit or contradictory beliefs described low SES, SPED, ELL, and/or struggling readers as less capable to engage in argumentation. Furthermore, teachers who believed all students are capable to engage in argumentation discussed supporting all students to participate at high levels in argumentation, but teachers with deficit and contradictory beliefs more often described support as lowered expectations for some types of students. Finally, teachers of low SES students discussed pressure from state standards and tests that impacted their argumentation instruction. While teachers of high SES students discussed similar pressures, they did not describe it as greatly influencing their students' engagement in argumentation.

Based on these findings, we suggest that teachers of low SES students may need support in two areas: understanding and engaging students in argumentation discourse and managing accountability pressures. We also suggest that all teachers need support to recognize that all students are capable of engaging in argumentation.

Teachers of Low SES Students: Beliefs About Discourse

Although all teachers appeared to value argumentation, we saw differences between the beliefs of teachers of high and mid SES students and teachers of low SES students related to argumentation discourse. While teachers of mid and high SES students believed argumentation should involve the types of student to student discourse and questioning prioritized by research (Berland & Reiser, 2009; Driver et al., 2000) and reform documents (NGSS Lead States, 2013; NRC, 2012), most teachers of low SES students described argumentation as an opportunity for students to express their ideas, which they rarely do in school. This type of talk is fundamentally different than argumentation, however, which prioritizes student-to-student discourse (Duschl & Osborne, 2002). The consideration and critique of multiple competing explanations through argumentation makes student thinking visible and supports greater sense making of the phenomenon under study (Berland & Reiser, 2009).

The concept of "noticing" could potentially be productive in designing professional development that addresses the benefits of argumentation discourse. Sherin, Jacobs, and Philip (2011) assert that "noticing" is a key process for teachers as they make instructional decisions, and it encompasses both what teachers pay attention to (and do not pay attention to), and how teachers actively make sense of their classrooms. Teachers of low SES students may have noticed that argumentation requires far more student talk than they typically allow in their classrooms, or is the norm in their school. For teachers of high and mid SES students, where student talk is likely much more prevalent (Lareau, 2011), they may have noticed the differences between student oral participation and student-to-student discourse. Therefore, our findings point to an important role for teacher education to help teachers of low SES students "notice" student-to-student interactions in which they build on and critique each others' ideas. Opportunities to analyze and discuss video in professional development have been shown to be useful in this regard (van Es & Sherin, 2002).

However, "noticing" alone will not suffice. Teachers have to act on these noticings and be willing to shift the power dynamics in the classroom (Ford, 2008) so that students debate with each other, not just through the teacher. While teachers must scaffold these opportunities for students, and even teach explicit rules for discourse (Brown, 2004), they need to eventually step back and facilitate rather than control (Ford, 2008). Professional development that involves teachers in participating in argumentation experiences in which they debate claims, critique evidence, and persuade colleagues of their arguments could help teachers reimagine the roles of teachers and students in argumentation discourse (Borko, 2004; Zohar, 2008). Such opportunities support teachers in engaging in the crucial task of contrasting their instruction with the types demanded by argumentation and enable them to begin to understand the substantial shifts in instruction required by science practices such as argumentation (Reiser, 2013).

Teachers' Beliefs About Student Capability

Our findings suggest that teachers across all school types may need increased support to view all their students as capable of argumentation. Many teachers in our study from high, mid, and low SES schools expressed deficit or contradictory views of low SES

students, ELLs, SPED students, and struggling readers, believing they lacked the "background knowledge," "schema," or "experiences" to be successful at argumentation. Several of these teachers described lowered expectations or inappropriate "supports" or "scaffolds" for these students. These beliefs and instructional decisions mean that students will not only fail to benefit from argumentation, but may also internalize these teachers' deficit beliefs, often termed the hidden curriculum, further negatively impacting their educational experiences (Bennett & LeCompte, 1990; Giroux, 1981).

These findings related to scaffolds also confirm research by Pea (2004) that this term is ubiquitous and often used inaccurately. Pea (2004) defines a scaffold as a way to "enable the learner to do more than he or she would alone" (p. 429), but many of the teachers in this study described scaffolds as engaging some students in lower level cognitive tasks. Therefore, teachers may need opportunities to explore the types of scaffolds that are appropriate for argumentation, and how to use them to engage students in this cognitively demanding practice. For example, providing students with a specific writing prompt describing high-quality evidence can support them in written argumentation (McNeill, 2009) whereas open-ended questions can support student-to-student interactions (McNeill & Pimentel, 2010).

Our findings also suggest that teachers of low SES students can believe their students' home experiences preclude their successful participation in argumentation. These teachers often described their students as having academically unsupportive homes or homes where adults do not encourage appropriate effort and motivation for school. They asserted that these home experiences negatively impacted their students' abilities to engage in argumentation. These teachers may not believe that "the lived experiences of [these] children have value in learning and doing science" (Bouillion & Gomez, 2001, p. 895). Teachers need opportunities to learn how to leverage students' experiences and interests and engage them in scientific argumentation. For example, research shows that when such students are provided with experiences that engage them in science that is problem based, rooted in their community, and that enables them be "producers" instead of "users" of science, they are motivated, engaged, and highly successful (Fusco, 2001, p. 872). Argumentation can align with this aim, but teachers must first believe their students can participate in this practice.

These beliefs about home environment also relate to the concerns some teachers of low SES students expressed about engaging their students in oral argumentation. These teachers stated that students are often "off topic" or lack appropriate discourse skills for argumentation. Research has shown that the discourse styles of low SES students often differ from those of their teachers (Brown, 2006; Edmin, 2011). Therefore, what teachers interpret as off topic or out of control may actually be the ways that these students effectively communicate in the classroom. Creating classroom norms and routines that support effective discourse is a challenging task (Driver et al., 2000), and a focus on scientific practices, especially argumentation, requires teachers to find ways to connect students' discourse styles with scientific discourse (Gilbert & Yerrick, 2001).

Such beliefs may also be connected to teachers' instruction of ELL students. Schools with low SES students are more likely to have higher populations of ELLs (Consentino de Cohen, Detering, & Clewell, 2005), and teachers may be struggling to meet the demands of teaching such students a language-rich science practice such as argumentation (Lee, Quinn, & Valdez, 2013). For low SES teachers, therefore, it is crucial that professional development supports them in learning strategies for addressing science and language learning simultaneously in the classroom (Lee & Buxton, 2013) as they shift their beliefs about the capabilities of their low SES students.

Teacher beliefs, however, are not easy to change (Fullan, 2007), even when new standards or curriculum demand a shift (Spillane, 2004). Professional development needs to provide

teachers with opportunities to participate with their colleagues (Hargreaves, 1994; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003) to confront their current beliefs and reflect on their origins (Fetters et al., 2002). Only when teachers become dissatisfied with these beliefs will they start to seek alternatives (Pajares, 1992; Posner, Strike, Hewson, & Gertzog, 1982). Professional development with these and other research-based design features such as sustained time, focus on student learning, and modeling of instruction (Wilson, 2013) have been shown to successfully impact teachers' beliefs about science teaching and learning (Lumpe, Czerniak, Hany, & Beltyukova, 2012). Such professional development could utilize the vignettes of fictional students that we used in our survey and interviews. This type of activity would first enable teachers to make their beliefs explicit, and then serve as a "bridge" (Davis, 2003) between current beliefs and the types of beliefs that teachers must develop to engage students in argumentation. While this is a complex and time-consuming process, our findings and previous research (e.g., Loucks-Horsley et al., 2003) indicate that reflective experiences are likely an important component of teacher learning opportunities during professional development.

Our findings also suggest that these vignettes could be more useful as Likert scale items if they include more variation in the descriptions of students, including some without positive attributes. For example, the Abby vignette could be changed to state that while Abby has attended multiple schools, she rarely participated in previous science classes. Using a variety of such vignettes may enable teachers to express wider and more nuanced beliefs instead of only providing a socially acceptable answer. The design of such measures is an important area of future research.

Teachers of Low SES Students: Beliefs About Standards and Tests

The deficit beliefs some teachers in low SES schools expressed about students' home lives may also be partially explained by pressure teachers experience from district and state accountability policies. Costigan (2005) theorized that teachers can possess negative views of their students' home lives due to "a complex shielding and coping mechanisms on the part of teachers due to increased accountability and severely diminished power and autonomy to teach as they think best" (p. 132). Several of the teachers in low SES schools described the ways district policies dictate their teaching, with little room for deviation. Such pressure may also contribute to the alignment these teachers discussed between argumentation and test-taking skills. Some teachers of low and mid SES students discussed argumentation as supporting answering open-ended questions and choosing the correct multiple-choice answers on tests. While these benefits to test taking are possible, argumentation is part of what Kuhn (2005) describes as a "thinking curriculum" that engages students in higher order cognitive skills. Therefore, selecting the correct answer for a multiple-choice item focused on science facts is not the same as engaging in scientific argumentation. As such, while teachers may see these connections because of the pressure they experience to ensure students do well on standardized tests, there is a danger that forging associations between standardized tests and argumentation can cause teachers (and students) to develop misunderstandings about what counts as argumentation in the classroom.

Our findings also build on previous research that demonstrates that high-stakes assessments can impact classroom instruction for teachers at low SES schools more than high SES schools (Diamond & Spillane, 2004; Peabody, 2005). Therefore, while the *Framework for K–12 Science Education* (NRC, 2012), which guided the development of NGSS (NGSS Lead States, 2013) prioritizes engaging *all* students in science practices such as argumentation, our findings should serve as a caution that excessive pressure to meet standards or have students achieve on tests may inadvertently impede teachers' abilities to do

so (Finnigan & Gross, 2007). Removing or altering this pressure could in part alleviate the need teachers of low SES students may perceive to connect argumentation instruction and these policies. We suggest that this may be at the root of some of the argumentation conceptions and beliefs of student ability expressed by teachers of low SES students. The design and implementation of assessment systems that reflect the types of science learning called for by NGSS (Pellegrino, Wilson, Koenig, & Beatty, 2014) would be instrumental in this regard.

LIMITATIONS AND FUTURE WORK

Our study focused on the argumentation beliefs of teachers of low, mid, and high SES students. While this study did not observe or measure teachers' enactments of the curriculum and therefore cannot assess how much or how well students actually engaged in argumentation, we assert that the specific beliefs expressed by the teachers in our study are important to consider if we want to support teachers in engaging all their students in scientific argumentation. While we focused on teacher beliefs because they have been shown to contribute to their decisions about classroom instruction (Pajares, 1992), our limited knowledge of the backgrounds and experiences of these teachers precludes any conclusions about the sources of these beliefs. Future research should explore this as well as the ways that teachers' backgrounds may interact with their beliefs about their students' home lives. This is an important next step given our finding that teachers of low SES students can hold deficit views of their students that may impact their willingness to include argumentation in their classroom instruction.

While our participants were diverse in terms of geography and teaching experience, our sample also had three important limitations. First, our incomplete knowledge of these teachers' backgrounds means that these teachers may not be representative of a greater population of teachers in the United States. Second, our choice to explore how the beliefs of teachers of high, mid, and low SES students align and differ means that our sample sizes in each group were small, especially for teachers of high SES students. We do not believe that this diminishes the significance of our findings, but may reduce the generalizability of our results. Third, our choice to categorize teachers based on three broad groups, low, mid, and high SES of students, means that we may have missed important nuances in the data. Future research that breaks down these groups in terms of other factors, such as aspects of teachers' backgrounds or resources available in schools, could provide a more detailed and in-depth understanding of the relationships between teacher beliefs and student SES. In addition, we suggest that future research gather data before and after teachers enact an argumentation-focused curriculum so that the reciprocal nature of practice and beliefs (Haney et al., 2002; Levitt, 2001) specific to argumentation can be better understood. Such research should also consider how argumentation is framed for teachers during professional development prior to their instruction of new curricula. Our lack of knowledge about how the benefits and instruction of argumentation were communicated to teachers in their brief professional development before enacting the curriculum is another limitation of this study.

CONCLUSIONS

All teachers in this study believed argumentation was an important learning goal for their middle school students. However, *why* teachers believed argumentation was important and their beliefs about individual *student capabilities* varied. Teachers of low SES students saw different goals for student talk than teachers of higher SES students, suggesting their beliefs are more likely to align with "pseudoargumentation" (Berland & Hammer, 2012;

McNeill, Gonzalez-Howard, Katsh-Singer, & Loper, 2016). As such, teachers of low SES students may hold beliefs that focus on the surface-level features, rather than a more in depth understanding of this science practice such as the sense making and critiquing elements. One reason for this difference may stem from the greater pressures teachers of low SES students feel from accountability measures on their classroom instruction. Such accountability pressures may also be impacting teachers of low SES students' beliefs about student capability to engage in argumentation. While we found that teachers across school types can hold deficit or contradictory beliefs about students' capabilities to engage in argumentation, teachers of low SES students were unique in ascribing such deficits to students' home lives. As the nation's student diversity continues to grow, important steps will need to be taken to make the NGSS accessible to all students (Lee, Miller, & Januszyk, 2014). Our work suggests that all teachers, particularly those teaching in low SES schools, need greater support around the more cognitively challenging aspects of argumentation, as well as potentially the other science practices.

This research was conducted as part of the Constructing and Critiquing Arguments in Middle School Science Classrooms: Supporting Teachers with Multimedia Educative Curriculum Materials project, supported in part by the National Science Foundation grant DRL-1119584. The design of the earth science curriculum was funded in part by a grant from the Bill & Melinda Gates Foundation. Any opinions expressed in this work are those of the authors and do not necessarily represent either those of the funding agencies, Boston College, Lawrence Hall of Science, or the University of California, Berkeley. We would like to thank Jeremy Price and Maria Gonzalez-Howard for their assistance in this work.

APPENDIX

INTERVIEW PROTOCOL

1. What are some of the benefits you believe your students gain from engaging in scientific argumentation?
   a. What are some of the drawbacks, if any?
2. Do you think you accomplish any additional educational goals (besides learning science content) in engaging your students in argumentation?
   a. What are some of those goals?
   b. How are they accomplished?
3. I would like to talk about different factors that impact the way that you teach argumentation. Specifically, I am going to ask you to think about factors that may influence your instructional decisions related to argumentation.
   a. In what ways do the curriculum materials including the lesson plan and educative notes impact your teaching of argumentation?
   b. In what ways do your students' backgrounds and abilities impact your teaching of argumentation?
      i. *Probe if* ***only*** *mention backgrounds* ***or*** *abilities*: *You discussed the ways students' (backgrounds or abilities) impact argumentation. Do you also feel that students' (backgrounds or abilities) impact your teaching of this argumentation lesson? If yes, how?*
      ii. On your survey, you indicated that you believed student _____ was _____ capable to engage in argumentation. I'm going to read you the description of this student again. (*Read student example)* Can you explain why you believe this student is _____ capable?

   c. In what ways do your state standards and state test impact your teaching of argumentation?
   d. In what ways does support from other teachers, or school or district administrators impact your teaching of argumentation?
4. How successful are your argumentation discussions?
   a. On your survey (Q#19) you indicated that teacher _____ best aligns with your beliefs about facilitating classroom discussions. I'm going to read you the description of this teacher again. (*Read text.)* Can you talk a little more about why this is?
5. Do you learn about teaching argumentation from preparing and teaching lessons related to argumentation? Why or why not?
   a. Do you feel more confident to teach argumentation in the future after preparing and teaching this unit/units? Why or why not?
6. You indicated on your survey that (Q#21) the following 3 (*name his/her top 3 from survey)* most influence your teaching of scientific argumentation. Can you describe some of the ways this happens?
   a. Why do you believe these three have the most influence?
7. Do you have any suggestions about how the curriculum could better support teachers in teaching scientific argumentation?
8. Is there anything else you think we should know about your teaching of scientific argumentation?

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