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Negotiations in scientific argumentation: An interpersonal analysis

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Abstract

Argumentation enables students to engage in real world scientific practices by rationalizing claims grounded in supporting evidence. Student engagement in scientific argumentation activates the negotiation process by which students develop and defend evidence-based claims. Little is known, however, on the intricate process and potential patterns of negotiation between students during scientific argumentation. The present study seeks to fill this gap by exploring how a group of university science education students negotiated when evaluating the relationship between lines of evidence and alternative explanatory models of a phenomena (i.e., climate change). This research, theoretically grounded in social constructionism, used Halliday's model of Systemic Functional Linguistics (SFL) within a discourse analysis framework. The authors analyzed transcripts of student conversations during a model-evidence link activity to gain insights into patterns of negotiation. An interpersonal analysis centering on mood and moves revealed students' ability to engage in the negotiation component of scientific argumentation to make assertions about relations between evidence and models. Effective collaboration resulting in group consensus of the relationship (categorized as supports, strongly supports, or contradicts) was facilitated by the use of interrogatives, modulation, and a balanced contribution between group members. Conversely, negotiation which did not reach consensus featured less

balanced discussion among group members, contained more interruptions, more conflict moves, and double polarity clauses.

KEYWORDS
abductive argument, argumentation, discourse analysis, evidence based argument, negotiation

1 | INTRODUCTION

Recent reforms in science education have led to a restructuring of what it means to teach and learn science. These shifts in educational priorities are a result of a variety of research-based initiatives from the past half century that lead to the release of *A Framework for K-12 Science Education* (NRC, 2012). This framework made recommendations for major revisions in science teaching and learning, calling for combining science content, practices, and cross cutting concepts into an integrated and meaningful context. Reforms propelled by advances in cognitive and learning sciences and recommended by initiatives such as the *Science for All* movement of the 1980s failed to transform science classrooms beyond the traditional initiate–respond–evaluate practices of the early twentieth century (Ford & Wargo, 2012). An increasing body of evidence provided a compelling case for restructuring the teaching of science according to the vision laid out in the *Framework*, calling for student's classroom participation in the practices of science (e.g., engaging in argument from evidence, NRC, 2012).

Argument is an important aspect of how scientists co-construct understanding of natural phenomenon and participate in scientific reasoning, and is dependent on evaluating evidence-based claims (Brown et al., 2010). Two of the identified scientific practices are *constructing explanations* and *engaging in argument from evidence* (NRC, 2012). These practices are seen as critical for students to develop evidence-based reasoning skills and participate in the culture of science. According to the *Framework*, "In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon" (NRC, 2012, p. 52). Duschl (2008) emphasizes the importance of argument in science, claiming "arguments provide evidence for the justification of knowledge" (p. 284). Furthermore, argumentation is a key skill in science learning and teaching because it requires knowledge of scientific evidence and the use of such evidence to support claims (Henderson et al., 2018). Driver et al. (2000) emphasize the importance of teaching scientific argument for the advancement of scientific literacy which is required for participation in a democratic society. According to Osborne et al. (2019), argument "is potentially the most challenging...as it is the most unfamiliar and least used" (p. 1069) of the eight scientific practices.

Equally important is the role of student-to-student interaction in developing evidence-based reasoning skills. Duschl (2008) recommends the use of conversations as a means to help students better understand the relationship between evidence and explanation in scientific inquiry. These student-to-student interactions take on a broad range of applications when implemented in the classroom and include the argumentation genre. Henderson et al. (2018) suggested that there is a gap in the research related to understanding student discourse and social collaboration practices in scientific argumentation. Through examining linguistic patterns of student conversations while discussing the relationship between evidence and explanations, the present

study seeks to provide insight into how students evaluate and build consensus for the connections between lines of scientific evidence and alternative explanatory models through negotiation. Although some have argued that both adversarial (i.e., with the goal of trying to compete and win) and collaborative (i.e., with the goal of trying to collectively construct and problem solve) argumentation modes can result in learning, classrooms discussions focused on collaboration and negotiation toward consensus facilitate deeper scientific reasoning and knowledge construction most often (Mercier et al, 2017; Nussbaum, 2021).

The role of negotiation in argumentation is central to consensus building as students engage with and respond to each other's ideas (Berland & Lee, 2012; Jiménez-Aleixandre & Brocos, 2017). Negotiation facilitates argumentation by allowing students to construct and share ideas, build consensus and integrate questions and alternative explanations, and learn how to revise claims based on their strengths and weaknesses (Nam & Chen, 2017; Nussbaum, 2021). Duschl and Osborne (2002) suggested that "Science as a way of knowing... involves the use of critical arguments and processes that are more akin to diplomatic negotiation than to conflict" (p. 54). Negotiation then, is a subset of argumentation, where students present a position, agree or disagree with each other by offering explanations and counter arguments, and reach conclusions through civil discourse and conversation (Chen & Steenhoek, 2013; Nussbaum, 2021).

Although much attention has been given to argumentation in the K-12 classroom, it is important that these activities extend to preservice teachers in the undergraduate program. Research by Gilles and Buck (2020) demonstrated that students' discourse practices in argumentation are highly dependent on those of their teachers. They suggested that, "analyzing the discursive process preservice teachers use to construct arguments is a gap in argumentation research" (p. 306). Better understanding the discourse practices of these preservice teachers can help understand sensemaking in argumentation. Preservice teachers have difficulty implementing argumentation as a teaching strategy if they are not exposed to it. By engaging in argumentation activities that they will be expected to implement in the classroom, preservice teachers will better understand the use and implementation strategy of this important practice (Quinlan, 2020). By situating argumentation activities for preservice teachers in activities similar to those they are expected to use in teaching, they may be able to facilitate and implement argumentation through negotiation as an instructional strategy in their future classrooms (Osborne et al., 2019). How well the discourse patterns of these preservice teachers reflect the practices of K-12 students is one area that is rich for current and future research.

1.1 | Purpose of the study

The purpose of the present study is to better understand the process of negotiation that occurred between students as they engaged in scientific argumentation. More specifically, to understand how negotiations unfolded in the course of scientific argumentation, and how students evaluated the relationship between scientific evidence and explanatory models through a structural-functional approach to social linguistics. Understanding the negotiations that occur and exploring the types of arguments constructed when students evaluate connections between evidence and explanations provided insights about how students build critical thinking skills through argumentation. Kuhn (2010) presented a case for increased research into the nature and development of argumentation skills, especially when dealing with complex concepts. Further, Henderson et al. (2018) discussed a gap in the research related to understanding

"discourse moves that build sense-making culture" (p. 11) with both preservice and inservice teachers.

Argumentation frameworks, such as those proposed by Walton (2001) have been used to frame prior research on argumentation. Walton's framework views the process of argumentation through schemes, and specifically through a pragmatic perspective, where these schemes reveal "normatively binding kinds of reasoning seen as moves, or speech acts in the setting of dialogue" (p. 1). This aligns to the social aspect of scientific practice in which investigative communities "engage in public debates [arguments] about explanatory accounts of nature using socially negotiable but largely stabilized norms and means" (Ford & Forman, 2006, p. 4). These argumentation schemes all share a common feature of abductive reasoning (i.e., where epistemic judgments, such as the plausibility of a scientific explanation, is a reasonable, but tentative presumption based on the quality of evidence available at a given time). In Walton's schemes, epistemic judgments result from the process of dialogue interactions, such as negotiations that work to toward greater understanding for the entire group.

Argumentation with negotiation as a focus of inquiry has been a central research focus in some studies (see, e.g., Chen, 2011, Berland & Lee, 2012, Matuk, 2018). Further, many of these previous examinations of negotiation have often applied a sociological approach to analyzing discourse. For example, Baker (2009) said that negotiation is one way to co-construct knowledge via argumentative discourse. Likewise, González-Howard and McNeill (2020) suggested that students' roles as scientific sense makers are negotiated during classroom argumentation activities, with Grooms et al. (2018) finding that students differing views about a claim validity "required them to attempt to negotiate meaning by proposing, supporting, and challenging and refining ideas" (p. 1275). Finally, Chen et al. (2019) suggested that understanding of scientific argumentation was related to the social process of negotiation around uncertainty. However, to our knowledge, the social linguistics of argumentation through negotiation has not yet been explored using a structural-functional approach to inquiry. Student conversations provided a rich source of information that potentially yielded insights into how argumentation developed and evolved through negotiation, which can be effectively explored through a structural-functional approach to discourse.

1.2 | Research questions

- *How did students negotiate evaluations of the relations between lines of scientific evidence and alternative explanatory models of a phenomenon during an argument-based learning activity?*
- *What differences, if any, existed in the negotiations in which students reach consensus and those in which there was no resolution?*

For the present study, we used Halliday's system of Systemic Functional Linguistics (SFL)—as framed by Eggins and Slade (2001)—to analyze student transcripts of classroom conversation while engaged in an instructional scaffold, the Model-Evidence Link (MEL) diagram (Lombardi, Bailey, et al., 2018; Lombardi, Bickel, et al., 2018). We used SFL for analysis because it can provide a level of specificity that concentrates on structure and function of language, and has the potential to build upon and expand previous sociological approaches that have investigated negotiation in argumentation. Firth (2014) recognizes that there is currently little research into how arguments unfold in discourse through negotiation, and how they are linguistically structured.

2 | THEORETICAL FRAMEWORK

Understanding negotiations in language and conversation is effectively explored through the perspective of social constructionism as a theoretical framework. Social constructionism posits that knowledge and truth are constructed, not discovered, through social interaction. As individuals engaged in social discourse, a shared meaning and understanding of reality is defined and developed through social discourse. The role of language is critical in this social construction of knowledge. According to Andrews (2012), conversation is the vehicle used for developing shared meaning and is the, "most important means of maintaining, modifying, and reconstructing subjective reality" (p. 41). In science and science education, social construction of knowledge is often manifested through the cultural process of scientific argumentation. Further, social negotiation of scientific evidence and claims allows students to deepen their understanding of scientific knowledge and how consensus—achieved via negotiation—is used to build scientific knowledge (Duschl & Osborne, 2002). As argumentation is central to social construction of knowledge, negotiation is central to engagement in the practice of argumentation, and, consensus the desired outcome of negotiation (Chen, 2011).

SFL is a multilayered theory of language and is used for exploring how meaning is expressed through the structure and function of language in context, which can be useful in identifying how and when learners negotiate consensus through negotiation. SFL offers the opportunity to explore how conversations are constructed for the purpose of sensemaking, and how linguistic choices reveal patterns of meaning based on the structure and function of the language choices made in conversation (Eggins, 2004; Halliday et al., 2014). In the case of scientific argumentation, SFL can be used to reveal how groups make sense of the notion that the scientific community builds knowledge via negotiation in response to critical discourse. Chen (2011) advises that the construction of scientific knowledge is the result of collaborative discourse through negotiation, and that, "argumentation can be seen as persuasion or the interactions that occur between individuals when they try to convince an audience of the validity of their knowledge claims." (p. 11). SFL can provide the framework to explain the process of negotiation as persuasive argumentation.

SLF provides a fine-grained discourse perspective, where grammatical structures give meaning to language and choices are made based on functions identifying scientific knowledge construction. As such, SFL provides two major advantages to conceptualizing the social construction of knowledge through discourse. First, it is based on the principal that the structure and function of language are interwoven in a highly organized system that can be revealed through the systematic analysis of linguistic patterns used in context. Second, the notion of language as systemic provides the advantage of representing linguistic structures at different levels of conversational meaning (Eggins & Slade, 2001; Halliday et al., 2014). These multiple layers of meaning (metafunctions), are evident in the different speech functions which correspond to different linguistic functions. The three metafunctions of language as defined by Halliday are the ideational (topic), the textual (theme), and the interpersonal (role relations).

However, the frequency and type of speech functions alone is not sufficient to conceptualize meaning. The function that each grammatical structure serves in language (i.e., to reveal when supporting responses are enacting agreement and consensus) is also critical. By understanding the conceptual purpose of grammatical structures, we can more accurately describe and appraise the function of linguistic choices through analysis. According to Halliday, SFL provides a powerful interpretative advantage as, "a discourse analysis that is not based on grammar

is not an analysis at all, but simply a running commentary on a text" (Halliday, 1994, as cited by Eggins, 2004, p. 20).

SFL is useful for conceptualizing conversation because it provides a means for thoroughly analyzing all moves in a conversation, rather than just the illocutionary ones. SFL also serves as a theoretical basis in a well-defined grammatical structure that is grounded in contextual language and allows for conceptualizing interactions in discourse through the interpersonal metafunction. Beyond this theoretical conceptualization, SFL allows for rich description of meaning in an analysis of conversational moves. Eggins and Slade (2001) provided two justifications for analyzing conversations through an interpersonal perspective of SFL that support the notion that learners can deepen their understanding of science through argumentative processes. First, conversations are primarily a means of negotiation by which identities and relations are enacted; and second, the turn taking structure of discourse can best be explored through patterns of mood and conversational structure, which is part of the focus within the interpersonal metafunction.

In terms of negotiation and consensus building during classroom argumentation, speech functions reveal elaborations and extensions of ideas through discourse, with the mood revealing how group norms (e.g., consensus in knowledge building) are extended. The power of SFL emerges because it allows four major language patterns to be conceptualized in an interpersonal analysis: grammatical patterns of mood, semantic patterns of attitude and evaluation through modality, patterns across turns, and finally, generic structural patterns (Eggins & Slade, 2001). In the present study, mood, modality and turn taking through moves were analyzed using SFL theory as a vehicle for fine-grained exploration of the conversations of preservice teachers participating in the discourse of scientific argumentative discourse when negotiating meaning about Earth topics.

3 | METHODS

The role of language in the social construction of knowledge (i.e., within a social constructionism theoretical framework) provided the basis for using discourse analysis methodology (Durrheim, 1997; Gill, 2000; Potter, 1996). According to Gee (2011), discourse analysis is, "the study of language in use" (p. 8) and is based on knowing how language works in order to understand it. Durrheim (1997) suggested that discourse analysis is an appropriate methodology for a social constructionist framework because it, "aims to account for how particular conceptions of the world become fixed and pass as truth" (p. 181). Discourse refers to all forms of text and talk, which has a critical function in the co-construction of knowledge. As both constructed and constructive, discourse is designed for an interpretive context, with language choices varied and chosen to express meaning and intent (Gill, 2000).

As a social activity, argumentation strategies in science education depend heavily on conversation and dialogue (Chin & Osborne, 2010). In science, there is a highly specialized vocabulary for academic language that students often struggle with, and as such, discourse analysis has proven useful as a methodology for past studies in which students are engaged in academic dialogue (see, for example, Temple & Wright, 2018). According to Potter (1996), research questions asked in discourse analysis can often be best explored by analyzing conversations. Conversation is the currency of learning in classrooms and Hammond (2013) suggested that discourse analysis with a focus on linguistics, "is central to understanding ways in which knowledge in constructed in classrooms, ways in which learning occurs (or not), and ways in which

interpersonal relations are constructed and enacted in classrooms" (p. 292). Discourse analysis is concerned with conflicts that arise in social interactions, with an emphasis on the "ways in which all discourse is organized to make itself persuasive" (Gill, 2000, p. 176). Furthermore, discourse analysis can be used to reveal "how parties co-construct negotiation as an activity" (Putnam, 2010, p. 146). Thus, the use of discourse analysis within a social constructionism theoretical framework, aligns with the nature of the argumentation activity central to the present study and can reveal how patterns in negotiation unfold in social interactions.

This study is designed using a qualitative research approach and incorporates elements of Case Study design to compliment the SFL approach to discourse analysis. According to Yin (2009), case study research is most appropriate for questions related to *how* and *why* to explain a phenomenon or event. Cases are bounded systems in which data are purposely collected in order to maximize what can be learned from the context (Stake, 1995). In this study, the case is defined as a specific group of preservice teachers working collaboratively in a college-level Earth science course (SFL register) while engaged in the scientific practice of argumentation (SFL genre) with MEL activities. Prior to elaborating on these methods, we highlight the theoretical underpinnings justifying the present study, and specifically situate this theory within the contexts of culture and situation.

SFL is framed and enacted through social relationships, and is represented through lexical choices made in conversation (Halliday et al., 2014; Martin & Rose, 2007). Participation in the practice of argumentation relies on interpersonal negotiations and is fundamentally a social enterprise. Within SFL, the process of negotiation is a critical aspect of how meaning is constructed and revealed through conversational structure (Eggins & Slade, 2001). Using SFL to analyze language choices made argumentation through the negotiation process can provide new insights into the micro-dynamics of social interaction, using the interpersonal metafunction of SFL as a lens for analysis. Specifically, in this study, we used Martin and Rose's (2007) interpersonal metafunction as an appraisal analysis of student discourse and negotiation to better understand grammatical patterns of conversational structure during activities in which students are engaged in scientific argumentation and negotiation.

3.1 | Context of culture

All social contexts have their own discourse patterns and linguistic functions. To best understand how language is used, it is important to identify the context, or genre, in which a conversation occurs (Almurashi, 2016). Genre, in this application, refers to the nature of language as a purposeful and goal-oriented human endeavor that is used to achieve specific results (Eggins, 2004). In this study the context of culture, or genre, is the practice of inquiry in science education that is grounded in evidence-based explanations and argumentation (Hardy et al., 2010). Thus, argumentation is an important practice for engaging students in the process of evaluating scientific explanations and relating evidence to scientific models (Duschl & Osborne, 2002; Erduran et al., 2017). Argument, when included in the science classroom, provides students the opportunity to participate in a community of learners, engage in authentic learning, develop critical thinking skills using multiple discourses, and build metacognitive processes (Engelmann et al., 2018; Manz, 2015; Tippett, 2009). Based on earlier work suggesting the use of an *evidence-explanation continuum*, Duschl (2008) proposed implementing a dialectical discourse framework for students to participate in the scientific practices using conversation-based strategies. Dialectical arguments are based on what we know and how we know it (Duschl &

Osborne, 2002; Lazarou et al., 2017). These conversations are important in science learning to, "mediate the transitions from evidence to explanations, or vice versa, and thereby unfold discovery and inquiry" (Duschl, 2008, p. 280). Duschl (2008) further emphasized that participating in these conversation-based argumentation activities is important for students in learning to use evidence to evaluate models and in making judgments about what constitutes scientific evidence. Huff and Bybee (2013) present important considerations for promoting argumentation and student discourse in the classroom. These authors stressed the importance of student conversations as a means of exchanging ideas and connections in evidence-based argumentation.

Chen (2011) defined argument as both a "cognitive activity and a negotiated social act" (p. 13). In research exploring the negotiation patterns in oral and written scientific argumentation activities, Chen identified six different practices students engage in when participating in argumentation discourse: defending, supporting, rejecting, challenging, elaborating and information seeking. As student make, support and challenge claims, they work toward explaining their ideas and reaching consensus through shared knowledge construction using these strategies. Matuk (2018) emphasized the importance of the negotiation process in reaching consensus in scientific argumentation using, "sensemaking, articulation and persuasion" (p. 55). Reaching consensus is an important aspect of argumentation for the co-construction of scientific knowledge. When engaged in consensus building, students must participate in negotiations that help them build stronger arguments by addressing the counter-arguments offered by their peers (Berland & Lee, 2012; Chen et al., 2019). Failed arguments, according to Matuk (2018), are those in which students are unable to negotiate consensus due to misunderstandings, disagreements, or individual participants who are unable to articulate an adequate claims-based reasoning approach to their position.

3.2 | Context of situation

The context of situation, or register, is the basis for understanding the field, tenor and mode of language in constructing shared meaning. Field refers to the topic, tenor to the participants, and mode to the role of language in the context (Almurashi, 2016). According to Eggins (2005), understanding the context in which language occurs is critical to understanding its meaning. Language is situated and "only becomes intelligible when placed within its context of situation" (p. 88). In the present study the Context of Situation, consists of preservice teachers (tenor/participants) enrolled in an undergraduate college course who participated in scientific argumentation activities on climate change and fracking (field/topics), designed to negotiate the plausibility of alternative models based on evidence (mode/role). MEL diagrams (Lombardi, Bailey, et al., 2018; Lombardi, Bickel, et al., 2018) were used as an instructional scaffold to engage students in this negotiation. Walton's (2015) abductive reasoning framework is the basis for dialectical argumentation, a cornerstone of MEL activities (Duschl, 2008). This type of argument is based on the premise that scientific explanations and models are tenable and subject to change when new, contradicting evidence is discovered. The construct of plausibility, accepting the most reasonable claim for a phenomenon based on the available evidence, is central to abductive argumentation in MEL activities (Lombardi, Nussbaum, & Sinatra, 2016; Walton, 2001; Walton, 2015; Walton, 2019). Therefore, understanding what constitutes evidence is critical to the process of scientific argumentation, and when scientific claims are negotiated, the value of evidence is debated based on its "validity, provenance, and reliability" (Walton & Zhang, 2013, p. 12).

In the MEL instructional activities, students are presented with two competing scientific models (explanations) and four different lines of scientific evidence. Then in a collaborative argumentation activity, students are asked to make evidence-based and explicit plausibility judgments about alternative explanations related to a particular phenomenon (i.e., based on how well lines of evidence support a particular alternative). The present study used two different MEL activities covering the topics of current climate change and fracking, and in using this MEL, students considered how well four lines of scientific evidence about the phenomena presented in each MEL activity. Figure 1 presents a diagram of the instructional process for all MEL activities. The climate change MEL presented evidence related to global temperature increases and glacial ice decreases to support two alternative explanations: Model A: humans are the cause of these changes or Model B: increased energy from the Sun is the cause of these changes. In the second MEL activity, the phenomenon of increased earthquake activity was explored using evidence to support explanations related to Model A, which is that increases in earthquake activity in the Midwest are caused by fracking, or Model B, which states that normal tectonic activity is the most plausible explanation for this activity. The use of MEL activities aligns with recommendations from Chin and Osborne (2010) and Hardy et al. (2010) for using scaffolds in developing argumentation skills, and from Huff and Bybee (2013), for collaborative discourse in argumentation activities. As students negotiated the plausibility of different models based on the scientific evidence provided, they would have engaged in the practices of elaborating, challenging, defending, supporting, and rejecting; all core components of negotiation practices in oral argumentation (Chen et al., 2012). Thus, the discourse practice implemented in this study is scientific argumentation based on Walton's (2015) framework for abductive reasoning through negotiation (i.e., a process designed to evaluate alternative explanatory claims based on relations to evidence and to negotiate a consensus about which of the competing explanations is more plausible; Lombardi, Nussbaum, & Sinatra, 2016; Chen, Park & Hand, 2015) as a process designed to explain ideas, reach consensus, and provide evidence that supports claims.

As part of each of these instructional activities, students participated in negotiation through collaborative argumentation during which they were given four different lines of evidence, all scientific (i.e., empirical and peer-reviewed), that were used to evaluate the two alternative models. Students completed the MEL activities by placing arrows from the two models to the pieces of evidence in order to indicate varying judgments about the strength of each relationship. Both before and after the evidence is presented, students made plausibility judgments about each model. Finally, they were asked to write an elaborative explanation about how one or more pieces of evidence informed their plausibility judgment. Lombardi, Brandt, et al. (2016)

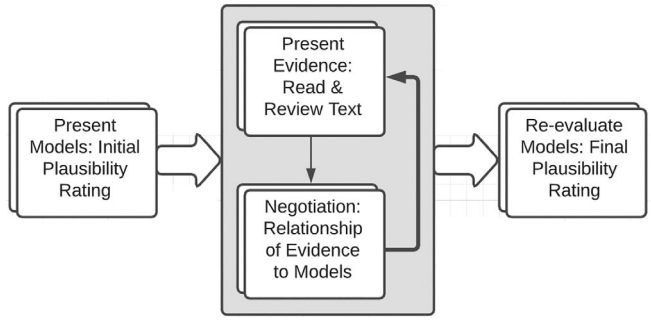

FIGURE 1 Instructional process for all model-evidence link (MEL) instructional activities

recommended including a collaborative conversation component to this activity to enhance student learning.

The language of science is part of the scaffold design by asking students to evaluate and negotiate the relationship of evidence to models in various ways. If the evidence supports the model, students decided on the strength of that relationship; does it support or strongly support the model? It is possible that the evidence could contradict the model, or have nothing to do with it? Students made these evaluations for each evidence to model connection through a group discussion activity. In these negotiations, students were expected to use the terms, "supports," "strongly supports," "contracts," or "has nothing to do with" to describe the relationship between each line of evidence and the explanatory models presented, and to reach consensus. Once all relationships were determined, students were asked to rerate (i.e., reappraise) the plausibility of the competing models and explain the basis for their judgments in an elaborative written task.

3.3 | Participants

The class in which this study was conducted consisted of six college sophomores and juniors in a science content course for preservice, middle grades teachers. Due to the class size there were just two student groups in the class, one consisting of three females (Group 1) and the other with two females and one male (Group 2). Although data were collected from both groups, one of the students in Group 1 was absent on the day of the first activity, leaving only two students in the first group participating in that lesson. In order to provide as diverse a group as possible and analyze data with consistent group members, we purposefully selected the group that was fully present for both sessions that included three students and had a mixed gender composition. Therefore, only the data on the larger, more diverse group (Group 2) was used for analysis. However, it should be noted that both the first and second authors found similar patterns of interaction with both groups in a preliminary analysis. The present study adopted an emic approach as the research centered on conversations that occurred within the lead researcher's classroom, thus granting a perspective from the position of an insider (Laws & McLeod, 2004).

Preservice educators were an appropriate group for this study. First, as undergraduate students they are likely to reflect the ideas, practices and attitudes of their future students. These future educators are a product of the educational system they have recently left, and their beliefs about learning science are not likely to have changed "significantly during the university education program" (Mellado, 1998, p. 198). Second, what preservice teachers do in training, they are likely to use in practice once entering the field. Therefore, it is important that future educators learn to, "effectively use curriculum materials as part of their teaching practice." (Schwarz et al., 2008, p. 347). Sadler (2006) emphasized the importance of preservice teachers participating in activities related to the scientific practice of argumentation because, "although argumentation is central to science, it is frequently absent from typical science classrooms." (p. 343).

Informed consent, in accordance with IRB approval, was obtained from students to record their conversations during the discussion portion of the activity during both units; the first on weather and climate and the second on geologic activity. The activities were modified from that developed by Lombardi (2016) as it was "gamified" to encourage collaborative discussion. Replacing the MEL diagram handouts, the game board included the explanatory models, evidence summaries, and instructions, as well plastic arrows to place on the board as students

negotiated the relationship between the lines of evidence and each model. Evidence summaries on the board corresponded with text summaries that included a written narrative, pictures, graphs, or illustrations to help explain the information summarized in the evidence statements.

3.4 | Data sources

The primary source of data collected for this study were transcripts for two sessions, both from a single group of students in the researcher's college level Earth science course for preservice teachers. Transcripts of classroom discussions were the primary data source for conducting conversational analysis. Although we obtained student work samples and video of the lesson, we did not use these data sources in the present study.

3.5 | Data collection

The first author recorded classroom conversations during the implementation of two different MEL instructional activities, using the climate change MEL and the fracking MEL (Hopkins et al., 2016; Lombardi, 2016). Eighteen minutes of classroom conversation were recorded during the discussion portion of the climate change activity, yielding 620 lines of dialogue when transcribed. Twenty-four minutes of conversation were recorded for the fracking activity, yielding approximately 460 lines of dialogue when transcribed. However, only relevant sections of discourse were used for analysis. According to Gee (2011), it is appropriate for the researcher to decide which parts are relevant to the analysis. Gee (2011) further recommended that segments that are most relevant to the research questions be selected for coding and analysis. The first and second author identified a total of six potential negotiation passages in each transcript for analysis. We defined negotiation passages as beginning at the first opening move after the oral reading of the explanation text, and ending when either the group reached consensus about the relationship between the evidence and one specific model in each discussion, or when the conversation moved to a new topic. Passages chosen for coding and analysis are the first four negotiations in the climate change activity, and for the first two and last two in the fracking activity. These eight passages are those in which students negotiated about a specific relationship between a line of evidence and one of the two competing models. In seven of these passages, students reached consensus about a specific relationship between the evidence and models by selecting one of the four, specific terms used in the activity (supports, strongly supports, contradicts, has nothing to do with). In the eighth segment, the negotiation was unresolved, with a decision that consensus could not be reached. In the remaining passages from both negotiations, students either were cut off due to time constraints before concluding their discussion, or evaluated the evidence in terms of both models simultaneously. These passages did not meet the criteria (complete negotiation of a specific model-to-evidence relationship) for analysis. Negotiation passages used for analysis are provided in Appendix A.

3.6 | Data analysis

The analytical framework of SFL described by Eggins and Slade (2001) for conversation provides the format and structure for the analysis in this study. According to these researchers, SFL allows for exploring the interpersonal aspects of language and the relationship between

language and context. Although based on Halliday's system for SFL, Eggins and Slade's adaptations for linguistic analysis are designed for the analysis of conversations as a lens to understanding the dynamics of social interactions. Eggins and Slade's framework is designed for casual rather than pragmatic conversations and the interaction of classmates has a casual level of formality that is well suited to this type of analysis (Eggins & Slade, 2001).

3.6.1 | Coding

In the present study, we transcribed data verbatim, then reviewed these transcriptions for a line-by-line confirmation of the text. We then coded the transcript using the system of SFL for conversational analysis as recommended by Eggins and Slade (2001) for conversation and presented above in the Data Analysis section. Analysis began with identification of the subject and finite within each clause, grammatical units which are the basic unit of discourse for coding in a conversation. The subject is the main person or thing about which the clause refers to and is required before negotiation can begin. The finite is the process part of the clause and usually the first word in a verbal phrase and is central to conversational analysis. Mood (sentence structure) was then coded for each clause. Subjects and finites were identified, polarity was flagged when appropriate, and terms related to modality labeled and classified using a spreadsheet to organize the data. Next, moves were identified based on speech function on a line-by-line basis. To explore patterns of negotiation in the data, we expanded each line of code to include a qualitative interpretation into the roles, relationships, attitudes and judgments that are characteristic of a qualitative, interpersonal analysis using SFL.

To provide a general overview of the data codes from each passage and to help provide insights related to the research questions, we combined data into two categories: (a) data from negotiations in which students reached consensus and (b) data in which no resolution was determined. A second review combined data from all the passages, regardless of negotiation outcome, to allow for insights into general patterns of negotiation in scientific negotiation using the MEL diagram for instruction. We used descriptive statistics to summarize code categories to reveal additional patterns for analysis and provide support for qualitative interpretations. While coding in an analysis based on SFL is determined by grammatical structure, interpretation is based on the function of language within its context (genre and register).

3.6.2 | Mood

In this analysis, role and related tensions within SFL's interpersonal metafunction are revealed through an analysis of mood, with associated modulators of polarity and modality. Coding for the overall mood of the conversation is determined by identifying grammatical patterns related to speech function. These include declarative, interrogative, exclamatory and imperative structures. The mood analysis structure provided by Eggins and Slade (2001) was used to code the data and is shown in Table 1 (mood). Mood refers to the grammatical structure of each complete clause. Clauses are complete phrases that contain both a subject (person or thing that is central to the action) and a finite (verbal element which indicates what the subject is doing). We used the speech functions in Table 1 to identify mood in the transcribed clauses. For example, in one of the negotiations one student asked another, "Are you positive?" This statement was coded as a *polar interrogative* as this is a question that can be answered with a yes or

TABLE 1 Codes for mood (based on Eggins & Slade, 2001, pp. 74–96) with sample coding from data

Mood	Function	Examples from Eggins and Slade	Example
Declarative (full)	To inform, challenge, state opinion, statement, refuse, comply, contradict	*He plays the double-bass.*	*This is all about normal plate tectonics.* Student 2, Session 2, Negotiation 1B
Declarative (elliptical)	Respond to a question, amend or add on to prior information; usually incomplete	*Everybody has to be, though.*	*I could see it going either way.* Student 1, Session 2, Negotiation 4B
Polar interrogative	Questions that can be answered with a "yes" or a "no"	*Did she see the photos in her coz?* *Does he?*	*Is it saying that?* Student 2, Session 1, Negotiation 2A
Wh-interrogative	Questions that ask information and include a "wh-" question word (who, what, where, how many, etc.)	*When are you going to do your general studies?* *Who?*	*So, what is the blue?* Student 2, Session 1, Negotiation 1A
Imperative	Commands and responses – don't usually contain a subject or finite	*Look at that man coming up the hill.*	*Look at what is in the full document.* Teacher, Session 1, Negotiation 1B
Minor	Clauses that no mood structure, brief in nature and minor	*Right.*	*Yeah.* Student 3, Session 2, Negotiation 4A
Abandoned	Incomplete thoughts *While not referenced specifically in the literature the authors suggest coding for them (p. 106)*	*N/A*	*But it talks about like....* Student 2, Session 1, Negotiation 1B

no. However, a different question, "So, what is the blue?" we coded as a "Wh-interrogative." Mood is useful for identifying the role each person plays in a conversation by determining the type and frequency of interactions. Analyzing conversations for mood allows for an understanding of roles through type of speech function, attitude and judgment through modality, and negotiations through reciprocity (Eggins & Slade, 2001).

Modality and polarity are dimensions of mood which can provide additional insights into how language is used. Polarity relates to whether a speaker asserts or negates a clause element. With the exception of minor clauses, polarity is either positive because it asserts a clause element or negative because it negates a clause element. While positive clauses are not specifically marked, negative clauses are indicated by expressing a "−n't" or "not" in the finite part of a clause (Eggins & Slade, 2001, p. 96). Modality provides a variety of choices for each speaker to temper language in the course of a dialogue through modalization (terms for probability and/or frequency) and modulation (terms for obligation, inclination and capability). Modal terms always appear in the finite section of the clause and allow for judgment, variation and uncertainty to enter into the conversation. Modality can be used to express certainty about a subject, or allows for a speaker to skew their words in a positive or negative direction. Modality allows

for negotiation, and in interpretation can provide clues to participant interaction by how each speaker asserts him/her-self through language, and within the context of culture or situation. Table 2 provides an overview of the coding process for modality, as suggested by Eggins and Slade (2001), and as used in the present study. Examples from the transcripts for both mood (Table 1) and modality (Table 2) come from the transcripts.

3.6.3 | Moves

The second dimension of the interpersonal metafunction explored in this analysis is the pattern of turn taking, confrontations, and support revealed through an analysis of moves. According to Hammond (2013), a "detailed account of patterns of interaction within classrooms" (p. 293) can be best understood through an analysis of student moves and turns. The analytical approach provides a nuanced level of refinement appropriate for conversational analysis (Eggins & Slade, 2001). Because each speech function can serve multiple purposes, this type of analysis starts by assigning new labels to each clause in the conversation based on the speech functions identified in the mood. For example, a declarative statement may be made to answer a question, give information, contradict an opinion or challenge a position. Although mood is more of an analysis of grammar and provides information about culture, speech functions in a move analysis examine the unfolding conversational purposes of language. Additionally, exploring data through moves can provide insights into relationships and how they are enacted in a conversation. In a mood analysis, the clause is the basic unit, while in a move analysis the discourse unit is a speaker's turn, which is further divided into "moves." Moves are defined as units, "after which speaker change could occur without turn transfer being seen as an interruption" (Eggins & Slade, 2001). Moves are based on both structure and function of clauses within discourse. The coding process involves examining the grammatical structure of a clause, then coding for language function in context, based on the role each move plays within a conversation using a hierarchal system of classification. There are several levels of refinement used in coding, pealing back layers of sophistication at each level. Initially, there are four basic types of moves: opening, sustaining, reacting/responding, and reacting/rejoining which are coded for each speaker's turn, with subclassifications that provide for increasingly refined nuances in the coding process. Opening moves in the context of argumentation often initiate discourse by stating an opinion, asking a question or offering information. Sustaining moves allow a speaker to elaborate on an opening move. Responses (react moves) can either be supportive or confrontational, and move the conversation forward (rejoining) or toward completing the negotiation (responding). After identifying the basic move category, more nuanced levels of meaning are determined depending on the mood and function of each clause in context. Thus, coding for moves gives insights into the fabric and structure of a conversation by revealing the function of language choices in conversation. Table 3 provides a summary of the coding structure used for analyzing moves in this study and is a synthesis of the coding structure presented by Eggins and Slade (2001). Figure 2 illustrates how this table was used in coding for this research (Table 6 provides a specific example of coding in the transcript).

3.6.4 | Validity and reliability

Validity in discourse analysis is based on the ability of the researcher to build on claims, arguing from evidence presented in the analysis. Analyses should include multiple tasks in the

TABLE 2 Expressions of modality (based on Eggins and Slade (2001), p. 107)

Type	Function	Sample terms from Eggins and Slade	Coding examples
Probability	How likely? How obvious?	*May*, *will*, *must*: *Probably*, *possibly*, *certainty* *Maybe*, *of course*, *surely*	*I don't feel like they even relate* Student 2, Session 2, Negotiation 1B
Incongruency	What thoughts? How certain?	*I'm sure*, *certain*, *I think*, *likely*, *probably*	*I think it's talking about irradiance* Student 1, Session 1, Negotiation 2B Note: In this case, "think" is used to indicate uncertainty
Usuality	How often? How typical?	*Usually*, *sometimes*, *always*, *never*, *for the most part*, *seldom*, *often*	*Didn't we already talk about that?* Student 2, Session 2, Negotiation 1A
Obligation	How required?	*Will*; *should*; *must*; *permitted*, *required*	*I would agree.* Student 1, Session 2, Negotiation 4A
Inclination	How willing:	*Will*; *gladly*, *willingly*, *readily*	*I think it strongly supports that it's fracking* Student 3, Session 2, Negotiation 4A Note: In this case "think" is used to indicated inclination to accept a position
Capability	How able?	*Can*; *is able to*; *capably*, *ably*	*Ok, but also this is talking about the sun's brightness.* Student 3, Session 1, Negotiation 2B

analysis that serve to provide broad support for conclusions drawn. In other words, validity is a function of the ability to support claims made in the analysis through evidence-based reasoning (Gee, 2011). Because the data are from a single group of students in a specific case, conclusions are not generalizable. Additionally, to address issues of reliability, the first two authors independently coded for both mood and moves using the analytical framework provided. Initial agreement for mood and moves was at 73 and 70%, respectively. In the second round of coding differences were compared and negotiated. When coding for mood, a majority of the differences related to whether the clause was elliptical or independent. Coding for moves required more negotiation and discussion. The mood provided information about the structure, but the function of each clause had to be considered. Eventually, through the process of negotiation, full (100%) consensus was reached by the first and second author using this collaborative coding process.

4 | RESULTS

4.1 | Overview

In this study, the structure of and relationship between mood, polarity, and modality were explored in order to better understand how students engaged in scientific argumentation

TABLE 3 Codes for moves (based on Eggins and Slade (2001))

Basic move category	Columns represent levels of sophistication in analysis increasing delicacy in description moving left to right			Clarification	Mood indicator
Open	Attend	Greetings	Salutation		Minor
	Initiate	Give or offer	Goods		Mood interrogative
			Services		Mood interrogative
		Demand command	Goods		Imperative
			Services		Imperative
		Information	Give fact		Declarative
			Give opinion		Declarative
			Ask fact	Open	wh-interrogative
				Closed	Polar interrogative
			Ask opinion	Open	wh-interrogative
				Closed	Polar interrogative
Sustain	Continue. *Initial speaker*	Monitor	Check	Keep engaged	Interrogative
		Prolong *single turn*, *multiple moves*	Elaborate	Clarifies	Declarative
			Extend	Adds/Extends info	Declarative
			Enhance	Qualifies/Modifies	Declarative
		Append *speaker loss turn then regains*	Elaborate	Clarifies	Nominal group
			Extend	Adds/Extends info	Nominal group
			Enhance	Qualifies/Modifies	Prep/adverb phrase
React respond *Moves toward completion. Usually elliptical Declaratives. No new subject/ finite*	Support	Develop *high level of acceptance of previous speaker's proposition*	Elaborate	Expands by restating, clarifying	Declarative
			Extend	Adds support or Extends Info	Declarative
			Enhance	Qualifies or Modifies	Declarative
		Engage		Agree, simple	Minor clauses

TABLE 3 (Continued)

Basic move category	Columns represent levels of sophistication in analysis increasing delicacy in description moving left to right			Clarification	Mood indicator
		Register		Agree, w/encouragement	Minor clauses
		Reply	Accept	Accept goods/ services	Nonverbal or minor
			Comply	Carry out demand	Nonverbal or minor
			Agree	Indicates Support	Minor
			Answer	Provide Info	Declarative
			Acknowledge	Indicates knowing	Minor
			Affirm	Positive response to query	Declarative or minor
	Confront	Disengage		Refuse to participate	Nonverbal or minor
		Reply	Decline	Rejects offer	Nonverbal or minor
			Noncomply	inability to comply	Declarative or minor
			Disagree	Negative response	Declarative or minor
			Withhold	unable to provide for demand	Elliptical declarative
			Disavow	Info deny acknowledgement	Expressions disclaiming
			Contradict	negate prior info	Declarative or minor
React rejoining *Sustains interactions uses queries or rejections*	Support	Track *interrogatives keep exchange open without confrontation*	Check	Elicits repetition	Elliptical polar interrogative
			Confirm	Verify what was heard	Elliptical wh-interrogative
			Clarify	Get additional info	Elliptical wh-interrogative
			Probe	Volunteer further details	Full clause, new subject

(Continues)

TABLE 3 (Continued)

Basic move category	Columns represent levels of sophistication in analysis increasing delicacy in description moving left to right			Clarification	Mood indicator
		Response *offered in response to tracking moves*	Resolve	Provide clarification	Elliptical declarative
			Repair		
			Acquiesce		
	Confront	Challenge *assertive*	Detach	Termination move	Nonverbal
			Rebound	Question relevance	Elliptical wh-interrogative
			Counter	Dismiss position	Nonelliptical declarative
		Response	Unresolved		
			Refute	Contract challenge	Elliptical declarative
			Rechallenge	Offers alternative position	Elliptical interrogative

Student 3 Asks: *Did it talk about….?*

BASIC MOVE CATEGORY	Columns Represent Levels of Sophistication in Analysis Increasing delicacy in description moving left to right			CLARIFICATION	MOOD Indicator
	Attend	greetings	salutation		Minor
		give or offer	goods		Mod Interrogative
			services		Mod Interrogative
		demand command	goods		Imperative
			services		Imperative
Open	Initiate	Information	Give Fact		Declarative
			Give Opinion		Declarative
			Ask Fact	Open ✓	wh- interrogative ✓
				Closed	polar interrogative
			Ask Opinion	Open	wh- interrogative
				Closed	polar interrogative

Coding note: This is an opening move, student 3 is initiating the discussion with a question that is asking for information using an interrogative mood. Note: Only the final level, "Ask Fact" is indicated in Table 7A.

Student 2 Responds: *Because it's saying how they're striking the same area in a short period of time.*

BASIC MOVE CATEGORY	Columns Represent Levels of Sophistication in Analysis Increasing delicacy in description moving left to right			CLARIFICATION	MOOD Indicator
React Respond *Moves toward completion Usually elliptical Declaratives. no new subject/finite*	Support	develop *high level of acceptance of previous speaker's proposition*	elaborate	Expands by restating, clarifying	Declarative
			extend	Adds support or Extends Info	Declarative
			enhance	Qualifies or Modifies	Declarative
		engage		Agree, simple	Minor clauses
		register		Agree, w/encouragement	Minor clauses
	reply		accept	Accept goods/services	Nonverbal or Minor
			comply	Carry out demand	Nonverbal or Minor
			agree	Indicates Support	Minor
			answer	Provide Info ✓	Declarative ✓
			acknowledge	Indicates knowing	Minor
			affirm	Positive response to query	Declarative or Minor

Coding note: Student 2 responds by answering, providing information to answer in a declarative mood. Note, only the final level, "Answer" is indicated in Table 7A.

FIGURE 2 Example of coding for Table 3 [Color figure can be viewed at wileyonlinelibrary.com]

through negotiation. These specific grammatical patterns are the tools of an interpersonal analysis through SFL, aimed at understanding the interactions and relationships between individuals engaged in conversation. Patterns of negotiation revealed in this analysis provide some important insights into how students negotiate relationships between scientific evidence and alternative explanatory models in the data analysis. First, in the course of the negotiation students continuously asked questions to help arrive at their conclusions. Slightly more than 20% of the clauses made by students were questions, with the majority of those polar interrogatives. Students also used modal expressions (i.e., kinda, really, could) throughout the discussions to advance their arguments; however, as each conversation progressed, the modulators used often showed a stronger degree of certainty as they moved toward reappraising a plausibility judgment for evaluations of the evidence to model relationship in each case. When exploring differences in negotiation between passages that resulted in consensus and those that were left unresolved, specific patterns emerged showing that negotiations that did not reach consensus had fewer questions and there were not as many exchanges in which all three students participated. Similar patterns were observed in both activities.

4.2 | Mood

Mood is a function of clause structure and explored through speech functions, polarity and modality (Thompson, 2013). In this study, an investigation of mood provides the most insight into how relationships between models and evidence are negotiated. As students present their arguments about the relationship of the evidence text to each of the competing explanatory models, questions are frequently used to negotiate. Students used questions to help provide information about the evidence in order to assist in the reasoning process, or to better understand each other's claims. Twenty-one percent of all complete clauses made by students are questions (23% in the first session, 19% in the second), with the majority (81%) being polar interrogatives (see Table 4). Questions add an element of civility to a discussion, whether or not a speaker is asking for more information (Wh-interrogatives) or clarification (Thompson, 2013). In this negotiation, students frequently asked questions for the purpose of clarification through the use of polar interrogatives. In one exchange, Student 1 made a claim that the evidence "proves" the information provided in Model A. Students 2 and 3 responded by asking for clarification if the relationship, "supports" or "strongly supports" the model. In another exchange, Student 2 asked about the evidence text, "Does it say anything about, like, humans in the problem?" Student 3 answered, "Um, no." The use of clarifying questions is one way in which students can move the negotiation forward by making sure they all are bringing the same resources to the discussion. This collaborative construction of knowledge is an important asset in scientific argumentation (Nussbaum & Edwards, 2011).

In these conversations, interrogatives are characteristically used as a means of politeness in the negotiation process. While discussing the relationship of the second line of evidence to one of the explanatory models, Student 1 made the claim that, "this is saying that our activity is what is causing this." Student 2 reacted by asking, "Is it though?" Student 3 reinforced the need for reexamination by adding, "Is it saying that?" Rather than confronting Student 2 with a declarative assertion, Students 2 and 3 chose to make a point in a much less aggressive manner; by asking a question that required a deeper probe of the evidence text. Student 1 did not take long to realize the judgment error and responds, "It's not. It's not saying that. You're right!"

When examining the use of interrogatives in these exchanges it is worth noting that there is a difference in the overall use of questions in the exchanges that reached consensus and those that did not. Although more than 20% of all moves in the consensus exchanges were questions (polar interrogatives OR wh-interrogatives), only 5% of the moves in the negotiation passage that did not reach consensus were questions. The difference in mood demonstrates a contrast in how these students challenged and probed each other for additional information in the two different types of negotiation. We discuss additional insights later with a more nuanced analysis of moves.

4.3 | Tempering language through polarity and modality

Polarity and modality are reflected in the mood and can provide insights into how speakers temper their claims. According to Thompson (2013), modality "does much of the argumentative work" (p. 78) by softening assertions. Throughout this activity, the students continually mediated their positions through the use of modulation and modalization (two different aspects of modality) with expressions of probability, incongruities, usuality, and capability. Probability in

TABLE 4 Mood structure in complete clauses

Mood	S1		S2		S3		T		Student total		Student + teacher	
Polar interrogative Session 1 and 2 data	2	2	3	1	2	2	1	0	7	5	8	5
Polar interrogative Combined data	4		4		4		1		12		13	
Elliptical polar interrogative Session 1 and 2 data	1	1	3	2	3	0	4	2	7	3	11	5
Elliptical polar interrogative Combined data	2		5		3		6		10		16	
Wh-interrogative Session 1 and 2 data	0	0	1	1	0	3	3	0	1	4	4	4
Wh-interrogative Combined data	0		2		3		3		5		8	
Wh-elliptical interrogative Sessions 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0
Wh-elliptical interrogative Combined data	0		0		0		0		0		0	
Total interrogatives Session 1 and 2 data	3	3	7	4	5	5	8	2	15	12	23	14
Total interrogatives	**6**		**11**		**10**		**10**		**27**		**37**	
Declarative Session 1 and 2 data	8	4	8	14	7	3	6	2	23	21	29	24
Declarative Combined data	12		22		10		8		44		52	
Elliptical declarative Session 1 and 2 data	10	8	8	9	9	11	3	0	27	28	30	28
Elliptical declarative Combined data	18		17		20		3		55		58	
Total declaratives Session 1 and 2 data	18	12	16	23	16	14	9	2	50	49	59	51
Total declarative	**30**		**39**		**30**		**11**		**103**		**110**	
Clauses Sessions 1 and 2	21	17	23	27	21	19	17	4	65	63	82	67
Total clauses	**38**		**50**		**50**		**21**		**128**		**149**	

this conversation was indicated by words such as *would*, *could*, and *maybe* and are the type of modulators used most frequently by these students, accounting for approximately 36% of all modal terms, with similar data for both of the two different sessions. Terms such as *pretty much*, *already*, *and really* were used for usuality. The only instances where the quality of capability was modulated in this conversation was when students used the term, *also*. Incongruities are a subclass of probability terms in which speakers use dependent clauses at the beginning of their turn to temper probability. In this discussion, students used terms such as *I think*, *I mean*, and *I*

guess to soften their claims. Inclination terms such as *know* and *think*, show willingness and degree of conviction in students' claims.

Table 5 shows the use of modulators by students in both conversations. It should be noted that all students used about the same amount of modulation and modalization in both discussions. The use of modal terms by these students in the conversation suggested that in the process of negotiation these students are tempering their assertions. These students used probability modulators the most, suggesting a potential lack of confidence in their assertions. When proposing an evidence to model relationship in one negotiation Student 1 stated, "Well, it *could* contradict it..." and later when trying to justify a different relationship offered, "I w*ouldn't* say...." Student 2 likewise tempered her assertions using modal terms, "*I think* it strongly supports because it shows quantitative evidence" and strengthened them when making final conclusions such as, "So then it *wouldn't really* relate to model A." Student 3 modulated by use of terms indicating usuality almost as often as she uses terms for probability, indicating more confidence and certainty in her assertions in the first conversation. For example, she asserted herself as she informs her peers, "It *just* doesn't have anything to do with it." There is more pronounced confidence expressed through different modulators in the word choices made by Student 3 in the first discussion. However, in the second conversation, this student almost exclusively (80%) used terms for inclination in modulating her assertions, softening her approach.

It should be noted that while confidence and certainty are often the mood expressed through the use of modulation and modalization, there are often other reasons why speakers choose to temper their lexical choices. Thompson (2013) notes that modulation, "may not indicate genuine uncertainty on the part of the speaker" (p. 76) and other potential reasons for modulation should be considered. In this case, it could be argued that the use of modulation served another purpose. In abductive reasoning, scientific explanations are explored in terms of their plausibility, or a judgment based on the best explanation (Sinatra & Lombardi, 2020). As students in these negotiations worked through the evidence text they were expected to make a plausibility judgment about which term (supports, strongly supports, contradicts, has nothing to do with) best described the relationship between the evidence and model. There were no "correct" answers, and based on the information presented and understood by the explanation text, their plausibility judgments shifted during the course of the activity to indicate reappraisal. Modal terms used in the first passage from the first activity (climate change MEL) show a progression from low probability to higher as the negotiation progressed. For example, Student 2 started with the suggestion, "They are *kinda* correlated," then later raised the stakes by claiming, "*I think* it strongly supports because it shows quantitative evidence" before closing out the discussion without the use of modality terms by stating the evidence "strongly supports" the model. Throughout this conversation there is also a progression of modal terms used by the collective group to show an increasing certainty in their plausibility judgment. Modal terms in this exchange move from, "*I think"* to, *"kinda"* then, *"would"* and finally to *"really."* Although the use of modality terms was not as evident in the third passage, the progression of terms was still apparent. Students started with "*I mean"* then, *"maybe,"* and "*would(not),"* then finally ended with *"really"*; each term indicating increasing certainty.

In the conversation for the fracking MEL activity, the first passage uses several modality terms that do not present a progression, while the last two are too brief to discern a pattern. However, the second passage is quite lengthy and provides sufficient data to note a progression of modality terms to demonstrate increasing certainty and confidence, similar to the pattern observed in the climate change activity. For the first 15 moves of the discussion these students

TABLE 5 Modulation terms used by students

Type	S1		S2		S3		Total	
Probability Sessions 1 and 2	4	4	3	4	3	1	10	9
Probability Combined	8		7		4		19	
Incongruities Sessions 1 and 2	2	0	0	0	1	0	3	0
Incongruities Combined	2		0		1		3	
Usuality Sessions 1 and 2	1	1	2	2	3	0	6	3
Usuality Combined	2		4		3		9	
Capability Sessions 1 and 2	1	0	0	0	1	1	2	1
Capability Combined	1		0		2		3	
Inclination Sessions 1 and 2	1	3	4	3	0	8	5	14
Inclination Combined	4		7		8		19	
Obligation Sessions 1 and 2	1	1	1	2	0	0	2	3
Obligation Combined	2		3		0		5	
Total Sessions 1 and 2	10	9	10	11	8	10	28	30
Total Combined	22		21		18		61	

exclusively use terms for modalization that express low probability (I think, I feel). As the conversation progressed, a greater variety and certainty are demonstrated with terms of modality such as *should* (move 19), *would* (move 21), *probably* (move 24) and *does* (move 41).

4.4 | Moves

The sequence of moves demonstrated by these students through negotiation show a complex set of interactions related to argumentation and explanation. Figure 3 provides a flowchart of potential moves observed as students engaged in the negotiation process. Codes from Table 3 are used to indicate the types of moves made by students as the conversation progressed. Opening moves most involved students asking questions or stating opinions to start the discussion and were evenly distributed among students, with all students opening at least one negotiation in each session. During the process of negotiation, students often moved back and forth

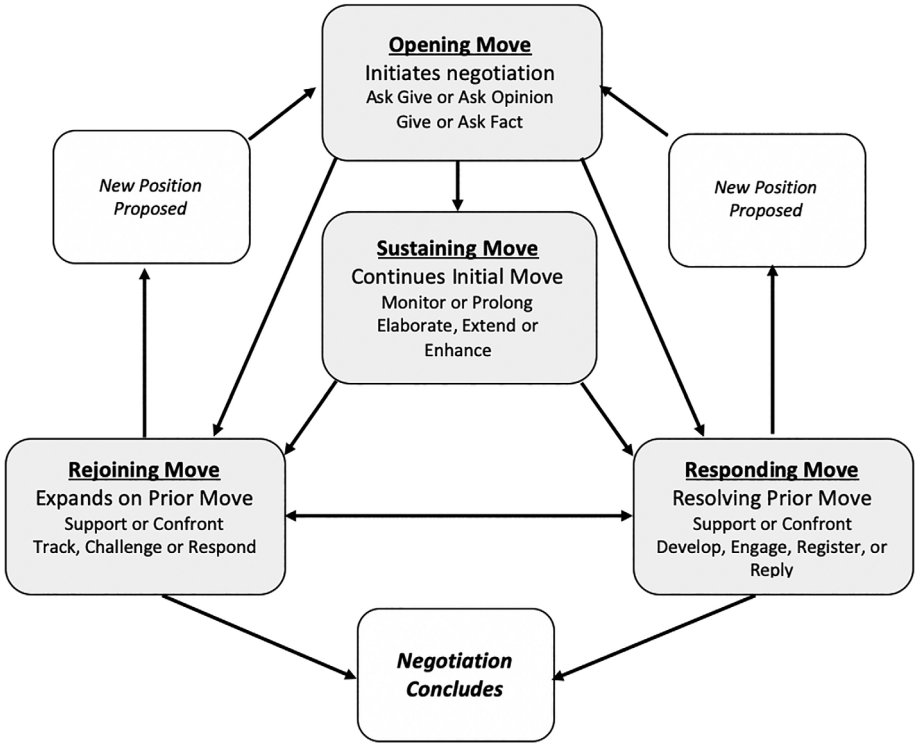

FIGURE 3 Moves in negotiation process

between responding and rejoining moves as the discussion played out. As the discussion played out either new positions were presented or conversations moved toward consensus.

Argumentation is defined by Nussbaum and Edwards (2011) as a "process in which claims are made, supported, and evaluated by reasons and evidence" (p. 444) and by Chen as both a "cognitive activity and a negotiated social act" (p. 13). Negotiation allows for the opportunity to elaborate on one's ideas, with the goal of reaching consensus through discourse about claims and evidence (Chen, 2011). Chinn and Clark (2013) described collaborative argument as a process by which students engage in dialogue in which they "typically make claims and support them with reasons" (p. 315). A variety of characteristics, including supporting evidence for claims, rebuttals, and qualifiers are characteristic of the argumentation genre (Nussbaum, 2008). Explanation and evidence are key characteristics of collaborative discourse for effective argumentation. Through an analysis of moves, these characteristics were evident in student negotiations. Claims are most often presented in opening moves, while rebuttals and qualifiers play out in a series of rejoining and responding moves. In the first discussion of the climate change MEL, Student 2 made the claim with collaborating support, "I think it strongly supports (Model A) because it shows quantitative evidence." The nature of that evidence, a graph with data related to atmospheric CO_2 concentrations and human emissions over time, is presented in the evidence text. Student 1 responded with a supportive move that developed then elaborated on Student 2's claim. Even in the passage in which students failed to reach consensus the same pattern of making evidence-based claims was apparent. Student 1 made the claim, "Well, it could contradict it by saying, (be)cause to say our current climate change is... caused by the Sun." When challenged by Student 2, this student offered a rebuttal, "Yeah. That could be, if

TABLE 6 Argumentation sequences

Student	Dialogue	Move (from Table 3)
1	Well, it *could* contradict it by saying...	Open: Initiate: Inform: Give Opinion
	Because to say, our current climate change is.... um... caused by the Sun	Sustain: Continue: Prolong: Enhance
2	You could be saying that humans have nothing to do with it.	Respond: Confront: Challenge: Rebound
1	Yeah, that could be.	Respond: Support: Reply: Agree
	If you're taking that as almost like an absolute.	Sustain: Continue: Prolong: Enhance

you're taking that as like, an absolute." The analytic framework from Table 3 describes these specific moves, which are illustrated in Table 6 and revealed a pattern of turn taking consistent with what is expected in negotiation through scientific argumentation. While responding moves are designed to bring a discussion sequence to a close, rejoining moves tend to move conversation forward. In this sequence, it is apparent that Student 1 attempted to present a claim, provide evidence to support it, and when confronted by Student 2 with an opposing claim, offers a rebuttal to address the challenge. These moves provided evidence that students are indeed engaged in an argumentation strategy whereby a claim is initiated, a rebuttal is offered and qualifiers presented. Although these characteristics of effective negotiations were apparent throughout both conversations, not all arguments were equally as successful.

4.5 | Consensus negotiations

The examination of moves within a conversation can also provide insights into the differences that occur in negotiations in which students reached consensus and those in which they did not. By sequencing moves "patterns of confrontation and support" are revealed (Eggins & Slade, 2001, p. 169). Most of the exchanges in this conversation made it is easy to parse out dialogue into a discernable pattern. One student made a claim or asked a question, and the other two responded with rejoining or responding moves (see Figure 3). Sometimes the teacher inserted a question, and again, student input was most often balanced equally between the three students. We acknowledge that these teacher questions may have impacted students' negotiations. However, to contain the scope of the present study (i.e., for making a more focused and succinct explanation of the negotiation phenomenon), we focused our analysis on student–student interactions.

Table 7(a,b) provide a list of the moves from Table 3 in two difference negotiations; in Table 7(a), consensus was reached in the negotiation, while Table 7(b) illustrates the sequence of moves in which consensus was not reached. In both of these tables, the coding for moves from Table 3 is reflected at the final level of refinement. For example, the opening move for Table 7 (a) when Student 2 asked, "So what is the blue?" codes at *Open – Initiate – Information – Ask Opinion*; however, only the last level of coding (*Ask Opinion*) was recorded for simplicity. Where more than one code has been used, it indicates that multiple clauses make up a single move. In the consensus negotiation (Table 7(a)), the moves shown for the first passage revealed a clear pattern of all three students involved at every stage of the negotiation. No student dominated the discussion at any point. Further, the teacher-to-student exchanges in moves eight to

TABLE 7 Student moves: Final level of coding for moves

(a)			
Session 1: Passage 1 (consensus)			
Move	**Student 1**	**Student 2**	**Student 3**
1		Ask opinion	
2			Answer and elaborate
3		Enhance and elaborate	
4	Engages (acknowledge)		
5		Counter and elaborate	
6	Engage and resolve		
7	Ask opinion and elaborate		
8		Answer	
9		Clarify (question)	
10	Answer and extend		
11		Gives opinion and extends	
12			Extends
13		Checks	
14			Answers
15	Rebound and clarify (questions)		
16		Answer (claim)	
17	Elaborates and extends		
18	Clarifies		
19			Engage (support)
20	Confirm (question)		
21		Answer (claim)	
22			Answer (agrees)
23	Answer (agrees)		
Session 2: Passage 1 (consensus)			
Move	Move	Move	Move
1			Ask fact
2		Resolve, answer, extend	
3	Acknowledge (agree)		
4	Probe		
5		Resolve	
6	Resolve		
7		Acknowledge	
8			Ask opinion
9	(Response) Unresolved		
10	Give opinion, enhance, extend		

TABLE 7 (Continued)

(a)			
Session 1: Passage 1 (consensus)			
Move	**Student 1**	**Student 2**	**Student 3**
11			Comply (agree)
12		Accept	
13	Accept		
(b)			
Session 1: Passage 2 (no resolutions)			
Move	**Student 1**	**Student 2**	**Student 3**
1	Teacher question (ask opinion/open)		
2	Register		
3		Register	
4	Answers		
5		Answers	
6			Agree and counter
7	Teacher question (check and enhance)		
8			Elaborate
9	Rebound and enhance		
10		Challenge: Rebound	
11	Agree and enhance and extend		
12		Reply: Answer	
13	Engage		
14	Teacher engage, elaborate, and extend		
15	Open (ask opinion) and check		
16		Noncomply	
17	Teacher: Qualify (command)		
19		Disagree	
19			Give opinion and extend
20		Check (question)	
21			Acknowledge
22			Extend and enhance
23		Agree	
24			Agree

Note: Multiple codes indicate more than one clause constitutes a single move.

ten were not directly related to the negotiation, but instead were related to clarifying the instructions. This pattern of equal participation, and constant exchanges between all three students was evident throughout the first conversations where consensus was negotiated, with Student 2 less involved in the third consensus discussion.

A move analysis of the one conversation where students did not reach consensus shows a different pattern. Student 2 seemed to dominate this negotiation. Table 7(b) shows a move summary during the second passage. During the first phase of this exchange, all three students seemed equally involved. However, after the teacher asked a tracking question to probe deeper student thinking (*Does it contradict it or just have nothing to do with it?)*, the interaction shifted to an exchange between Students 1 and 2. After the teacher interjects a third time in an attempt to clarify the expectations (*There's no wrong answer... just talk out your justification*), the conversation again shifted, this time to Students 2 and 3, with Student 1 disengaging.

Although Student 2 neither lead nor closed out the conversation, her dominant role in the conversation can be inferred from the number and type of moves presented. When examining these moves more closely, another theme emerged: Proscription, or an attempt to bring the conversation to end, with or without consensus. Early in the nonresolution conversation (Table 7(b)), Student 3 asserted that "It (the evidence) just doesn't have anything to do with it (the model)" (move 8). Student 1 challenged this claim by suggesting an alternative option, "It could contradict it..." (move 9) and tried to back up her assertion through a negotiation with Student 2 (moves 10–13). During this exchange, Student 2 cut off Student 1 with, "It has nothing to do with it" (move 12). Although the response indicated agreement, this is a "Respond – Support – Reply – Answer" move, which tends to indicate a shift in the conversation toward completion, as was also apparent in the briefness of this remark (Eggins & Slade, 2001); it is clear that further discussion was not invited. Later Student 1 asked, "Do you guys wanna take it as like it can either be one or the other?" (move 15, Open – Initiate – Ask Opinion – Open) which offered an acceptable option of not reaching consensus for this specific relationship judgment. Student 2 responded with, "No, I don't really have a preference" (move 16, Respond – Confront – Reply – Non-comply) in an effort to shut down the discussion. The double polarity of this statement further indicated an unmovable position in responding to her peer's question. This marked a turning point in the conversation, where Student 1 disengaged and did not participate throughout the remainder of the negotiation. After staying quiet during moves 9–18, Student 3 stepped in and tried to move the conversation forward again by offering an alternative, "I guess it contradicts it because.... the energy released from the Sun, it's like..." (move 19). However, Student 2 ignored this attempt and interrupted with, "So, you got one or the other?" (move 20). Student 3 responded with an acknowledgement, but then used an extension move to continue with the discussion (move 22). Student 2 again ignored this move, interrupted, and concluded the conversation with "Okay." It is apparent that Student 2 was in charge at this point and had no interest in pursuing this particular line of discussion further. The theme of proscription, or cutting off, was evident in the negotiation in which resolution as not reached, whereas it was not in the other three conversations.

When examining the number of moves each student made throughout both activities, all three students participated fairly equally in the first conversation (34, 34, 32%) while in the second activity Student 1 participated the least (29%) while Students 2 (39%) and 3 (37%) contributed fairly equally. In both, the overall participation by students and those that resulted in students reaching consensus, Students 2 and 3 participated equally (36% each), while Student 1 contributed fewer moves (29%). Yet in comparing passages where consensus was reach to those where no resolution was reached about the relationship of the evidence to the model, data show that Student 2 dominated the other two students in the unsuccessful negotiation (Students 1 and 3 30% each, Student 2 40% of the moves). Table 8 provides data comparing the percentage of moves each student made throughout the conversation, which provides insights into student dominance during each negotiation segment based on the move analysis. In the negotiation in which students were unable to reach an agreement (nonconsensus) about

TABLE 8 Student moves as a percentage of total student moves

	Student 1 (%)		Student 2 (%)		Student 3 (%)	
Student moves Sessions 1 and 2	34	24	34	39	32	37
Average moves combined	29		36		35	
Consensus negotiations	29		36		35	
Nonconsensus negotiation	30		40		30	

TABLE 9 Use of student rejoin/react-confront moves by negotiation

Negotiation	Outcome	Number of moves	Number of rejoin/ respond - confront moves	Percent of rejoin/ respond - confront moves (%)
Session 1				
1A	Consensus	23	1	4
1B	No resolution	24	5	21
2A	Consensus	18	2	11
2B	Consensus	14	0	0
Session 2				
1A	Consensus	8	1	13
1B	Consensus	49	4	8
2A	Consensus	8	1	13
2B	Consensus	13	1	8

the relationship between the evidence and the explanatory model, Student 2 was the dominant speaker. The combined data for mood, polarity, moves, and modulation reveals that this student also demonstrated multiple strategies to shut the discussion down without resolution (i.e., via response moves, double polarity statements and interruptions). Additionally, the move analysis shows a noticeable difference between the type of moves in the negotiations that resulted in consensus and those that did not, as presented in Table 9. Coding for moves shows that in the negotiation that failed to reach consensus, there was increase in the number of rejoin/respond-confront moves. While rejoin moves attempt to move discussion forward and respond moves work to complete a negotiation, those that involve confrontation tend to function as challenges or to counter other positions. The increase in rejoin/respond-confront moves during unsuccessful negotiations differs from successful negotiations that reached consensus in which students used these moves less often. In the subsequent negotiations for both activities, Student 2 returned to a more interactive stance in a more collaborative manner and participated equally in the discussions, with the original pattern of turn taking evident.

5 | DISCUSSION

Through an analysis of mood, polarity, modality, and moves, a number of patterns emerged that can provide insight into the discourse between students as they negotiate the relationship

of scientific evidence to explanatory models. The moves these students take verify a series of claims and interactions indicative of the practice of scientific argumentation. They present their position, back it up with evidence, offer rebuttals and count-arguments, and question each other as they evaluate the evidence to model relationship in their conversation. With the argument genre established through the pattern of moves in the data, it is possible to further address the research questions presented in this study.

How did students negotiate evaluations of the relations between lines of scientific evidence and alternative explanatory models of a phenomenon during an argument-based learning activity?

The patterns we identified indicate that students tended to present and argue their claims in a very tentative manner through the use of modulators. Probability and Inclination as terms of modality are used most often to soften assertions through terms such as *could*, *kind of*, and *maybe* for *probability* and *I think* or *I feel* for Inclination. When challenging each other's claims, the use of questions, rather than statements, served to soften their tone. These choices present evidence for the claim that these students were operating collaboratively as they negotiated evaluations in this activity. As students take turns moving through each discussion the choice of modulators they use generally transition from terms indicating less certainty (*it could*, *I think*) to lexical choices that show greater certainty (*would*, *should*, *probably*). Although the function of these terms indicated that this shift was likely related to greater confidence in their assertions, this shift may be a function of the abductive reasoning process. Specifically, students were asked to reappraise their initial plausibility judgments about the relationship between evidence and models during the course of a negotiation, and these expressions of confidence suggest that they moved to the more likely conclusion, while still allowing for some uncertainty (i.e., the "best" explanation based on the available lines of evidence reached through abductive reasoning).

These results address the importance of peer legitimization in argumentation. Berland and Lee (2012) explored how students reach consensus in argumentation through negotiation. They concluded that, "legitimizing one another's ideas enabled disagreeing students to feel more comfortable in changing their positions" (p. 17). In other words, politeness in negotiation, which was evident in the use of multiple means to temper language, allowed for students to feel as if they were being heard and understood and contributed to more fruitful consensus building. Language is important in legitimizing the ideas presented by others. The use of modulation and incongruities demonstrates the means by which language is used to soften assertions, and in turn, facilitate a safer environment for sharing and collaboration in argumentation.

What differences, if any, existed in the negotiations in which students reach consensus and those in which there was no resolution?

With one of the four exchanges representing a passage in which students did not reach consensus about the relationship between the evidence presented and the scientific model, it is possible to examine how these types of negotiations differ. Using an analysis of mood, it is apparent that students asked few questions during the exchanges in which they did not reach consensus. Because questions serve to prolong discourse and challenge assertions in a less assertive manner, the mood for unsuccessful negotiations has more tension. There were fewer questions used to soften the tone, more interruptions, and less participation. These findings align with research conducted by Berland and Reiser (2011) who concluded that students who focus on sensemaking, rather than persuasion, tended to ask more questions, while students who focus on persuasion engaged in more evaluation statements. Both sensemaking and persuasion are important elements in argumentation and are interwoven into any negotiation. Sensemaking in argumentation tends to focus on understanding claims, while persuasion is more related to critique.

In research exploring student discourse during argumentation, Berland and McNeill (2010) found that question and evaluation moves often do not occur in the same discussion. Although both type of moves are required for argumentation, the question of how well students are able to integrate both types of moves might be better revealed through this structural-functional approach to evaluating student discourse. Our findings revealed that the moves within the consensus negotiations involved a much higher percentage of questions (>20%) than those that did not reach consensus (5%). Clearly, both types of moves (question and evaluation) were apparent in the three negotiations in which consensus was reached; however, those that did not reach consensus employed fewer questions.

The careful analysis of moves reinforced this conclusion by demonstrating that during the most successful negotiations in which consensus was reached, all three students took turns in a more balanced interaction pattern. In the negotiation that did not reach consensus Student 2, while dominating this part of the discussion, engaged specific response moves, double polarity statements and interruptions, all of which are functionally designed to bring the discussion to a close. There was also a higher percentage of rejoin/respond-confront moves in the unsuccessful negotiation than in the other passages. The analysis of mood and move suggested a less collaborative pattern of interaction in the negotiation in which consensus was not reached. Ryu and Sandoval (2015) explored the gap in research on the role of social and interpersonal factors in argumentation and found that interaction patterns led to differences in group performance. These researchers extensively explored group interactions based on low and high-performance outcomes. Their results showed that groups with the lowest performance included group members who detracted from the group goals by dismissing, rather than evaluating, each other's claims. In the discussion that did not reach consensus in our study, we saw that pattern with Student 2, who used a variety of linguistic devices in an attempt to shut down the conversation. Further, the dominance of that group member in the negotiation illustrates the importance of balanced interaction in successful negotiations.

5.1 | Implications

This study addressed the recommendation for research on discourse and social interactions and collaboration in argumentation research. Ryu and Sandoval (2015) state a need for research on "the influence of social and interpersonal factors on collaborative argumentation" (p. 336). Henderson et al. (2018) made multiple recommendations for research, including exploring student discourse through social collaboration, and for building skills in argumentation for preservice teachers. Chinn and Clark (2013) discussed the importance of collaborative argumentation in the classroom. Learning through activities in which students jointly participate in making claims, supporting them and challenging others are all important practices for understanding the critical discourse of science, learning core content and participating in real-world practices. Although these researchers recognized a body of work already has been done on identifying argumentation structures, they suggest that not enough work has been done to understand the differences between good reasoning patterns and those that are less fruitful. They also recommended that specific learning situations be explored in order to understand argumentation in a variety of learning environments.

Through this study, patterns of mood have shown how interrogatives and modality are used by students in the process of tempering their claims while making plausibility judgments about the "best fit" relationship between lines of scientific evidence and alternative explanatory

models. Further analysis of student moves provided insight into how unsuccessful negotiations can be dominated by a single individual and various strategies used to bring discussions to a close without consensus. These patterns suggested that although students do understand that claims must be supported by evidence and can implement a variety of strategies to enhance collaborative argumentation, they also know, whether intentionally or not, how to conclude negotiations without resolution.

In the language arts classroom, Harman and Simmons (2014) describe research in which high students use SFL to better understand literary passages. They describe how high school students are better able to interpret narrative texts using SFL. In other research, Harman (n.d.) discuss approaches in which preservice teachers learn to use SFL in Language Arts and Social Studies to better plan and prepare for their future students. Harman and Simmons (2014) conclude that teacher education programs should provide their preservice teachers with the skills to analyze "the language and content demands of their academic disciplines" to better engage their students in meaningful ways (p. 21).

In much the same way that Harman and Simmons document the use of SFL in literacy learning, this research can be best applied by educators in science education as they implement argumentation strategies in the classroom. Teachers that can recognize linguistic patterns of constructive discourse and the socio linguistic practices that are most fruitful in sensemaking and negotiation, can better monitor and guide student discourse. By understanding patterns in modality, teachers may know what kinds of guiding questions to use to move discussions forward based on levels of certainty or confidence apparent in their language choices. Early recognition of inappropriate dominance or confrontational language patterns can help students navigate more successful negotiations. Encouraging semantics that soften assertions with modulation, and questions will help students develop skills in scientific argumentation. Both pre- and in-service teachers need to be able to listen, understand, elicit student ideas and motivate constructive discourse in argumentation. They must know what successful argumentation looks like, how it sounds and how it unfolds (Henderson et al., 2018). These skills do not come naturally (Chen, 2011) and require teachers that are able to provide cues to their students on how to engage in fruitful negotiation (Berland & Hammer, 2012). By developing a rich understanding of what successful social negotiation looks like at the structural-functional level, teachers can encourage the use of questions and modulation in scientific argumentation, and respond quickly when they observe strategies used by students that are designed to shut down collaboration. Additionally, future research efforts should be directed at building instructional scaffolds, strategies and professional development experiences that would help both preservice and inservice teachers recognize and provide instruction in linguistic patterns that facilitate collaborative negotiation patterns.

6 | CONCLUSION

This study builds on the work of others by exploring the discourse practices using a structural-functional approach to discourse analysis and was unique in its approach and findings because it revealed micro-level dynamics that resulted in students' sensemaking. The present study provided insights that justify the need for research into the patterns of discourse that occur during collaborative argumentation and empirically testing the feasibility of getting teachers to recognize these patterns. Examining differences in discourse strategies for different types of instructional scaffolds and at different levels (especially K-12 education) might reveal useful insights to

inform instructional practice for collaborative argumentation. More understanding of how discourse unfolds when collaborative negotiations are not successful can provide a framework for instructional intervention. Exploring the role of teacher–student interactions through the perspective of SFL might also yield valuable insights into questioning strategies that are most effective in facilitating student argumentation. Methodologically, exploring the data from an Ideational perspective within SFL could provide insights into how students think about the scientific models they are evaluating and the evidence being presented. Although the conclusions from this study are not generalizable, they do provide some insights that suggest that not only is SFL a useful framework from which classroom discourse can be studied, but that more research can only provide insights that can improve classroom practice through abductive reasoning activities and collaborative argumentation.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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