

**The Nature of Teacher Questioning Roles while
Supporting Dialogue and Argumentation**

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ABSTRACT

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This study examines discourse in physics classes in Finnish lower secondary schools. The goal of the research is to describe how student argumentation can be supported by a variety of teacher discourse, including different communicative approaches and teacher questioning roles. By describing specific features of successful episodes of student argumentation, the hope is to convey a more concrete image of effective instruction, inspiring further research, professional development, and self-reflection by practicing teachers.

The methodology utilized in this study approached discourse from multiple levels, aiming to describe the nature of communicative acts in a broad sense as well as in a more specific, moment-by-moment fashion. Discourse analysis was performed on four recorded lessons taught by two teachers aimed at supporting dialogicity and argumentation. The analysis included evaluating discourse based on the type of communicative approach used by the teacher, the teachers' questioning roles, and the level of student argumentation. Lastly, microanalysis of excerpts of the transcript was included to offer closer insights into the nature of teacher/student interactions.

The results of the study show that teachers use a variety of questioning roles in their discourse, but also suggest that not all questioning roles were equally effective at supporting student argumentation. Including a greater variety of questioning roles including moderator, coach, and participant was effective in supporting high-level student argumentation. Closer analysis revealed specific tactics that teachers use when playing various roles in the classroom. The study implies that teachers can utilize multiple roles in order to support student argumentation.

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1 INTRODUCTION

In order for deep, meaningful learning to take place in the science classroom, teachers must draw from a broad repertoire of skills, strategies, and expertise. Recent trends in science education research stress the importance of including students as part of the knowledge construction process, supporting the creation of conceptual links between different portions of content, and developing students' argumentation skills (Scott, Mortimer, & Ametller, 2011; Osborne, 2012). In order to achieve these goals, teachers should be mindful of the types of communicative approaches (Mortimer & Scott, 2003) and teacher questioning roles (Chen, Hand, & Norton-Meier, 2017) used in the classroom. Although there is a clear need for argumentation in the science classroom, explicit descriptions of effective practices for creating high-quality argumentative discourse have yet to be developed (Lehesvuori, Viiri, Rasku-Puttonen, Moate, & Helaakoski, 2013; Osborne, 2010).

In the science education context, Osborne (2010) describes argumentation as "collaborative discourse where students engage constructively with each other's ideas," and states that argumentation offers "a means for improving the quality of the student experience, the depth of student thinking, and their learning of science itself" (p. 466). As the argumentative process consists of collaborative interactions, dialogue is an inherently necessary component of classroom discourse in order to encourage high-quality student argumentation. Mortimer and Scott (2003) characterize classroom talk into four classes of communicative approach by classifying verbal interactions along two dimensions: interactive/non-interactive and authoritative/dialogic. In a similar fashion, Chen et al. (2017) classify classroom talk along two dimensions, focusing on how the ownership of classroom activities and classroom interactions can transfer between teachers and students. Within this conceptualization, four discrete teacher roles emerge, each of which aims to serve specific pedagogical purposes in facilitating argumentation and dialogue

in the classroom (Chen, et al., 2017). While Mortimer and Scott (2003) offer a way of analyzing classroom communication in a broader sense, this study also focuses on the different roles that teachers play, allowing for a closer look at teacher's habits and their effects on student's cognitive performance. This research includes microanalysis into teachers' use of the different communicative approaches and questioning roles to provide insight into best practices and strategies for promoting argumentation in the classroom.

In chapter 2, I draw from ideas presented by Osborne (2012) and Chen and Steenhoek (2014) to contend that argumentation is a vital practice that needs to be emphasized in the science classroom. I then introduce the concept of communicative approach, and discuss how intentional shifts between communicative approaches are necessary in order to support argumentation, and how classroom discourse reflects notions of classroom control and authority. The selection of communicative approach is then related to teacher questioning roles and pedagogical link-making. As teachers face significant challenges to supporting dialogic instruction and argumentation (McNiell, Gonzalez-Howard, Katsh-Singer, & Loper, 2016), I also clarify how the intentional use of communicative approaches, teacher questioning roles, and the quality of argumentation can be analyzed and understood.

The task of promoting dialogue and argumentation in the classroom is a highly intricate process and is not very clearly defined or understood (McNiell et al., 2016, Osborne, 2010). Because these instructional elements are highly valued yet misunderstood, it is important to conduct further research into the intricacies of how the use of different communicative approaches can support student argumentation. The aim of this research is to gain a deeper understanding of how teachers use dialogue and questioning roles to support student argumentation, with implications for teacher training, professional development, and classroom instruction.

The focus of chapter 3 pertains to the research questions which have served to guide this study. In Chapter 4 the methodology is reviewed, starting with the research design and moving to methods of discourse analysis. The

results from the study are introduced in chapter 5, including microanalysis to illustrate the nature of discourse in the classroom. Lastly, the quality of the study is discussed in chapter 6 and closes with reflections and implications for practice.

2 LITERATURE REVIEW

The process of learning science ideally involves not simply gaining knowledge of specific scientific phenomena, but also developing an understanding of the process of discovery that has led to current scientific theories. The initial process of discovery has already taken place concerning the majority of scientific phenomena taught in a secondary science classroom (Driver, Asoko, Leach, Mortimer, & Scott, 1994), so science content is often taught in a dogmatic fashion, rather than as a process of discovery (Osborne, 2012). Osborne argues that the authoritative presentation of content in a science classroom does a large disservice to the nature of science and the nature of learning itself. Rather than viewing students as passive recipients of knowledge, a more Vygotskian perspective should be adopted in the science context, with students included as active players in the construction of knowledge. Learning in science is to be a discursive process, where student learning occurs on both an individual and a social plane (Driver et al., 1994). In order to facilitate this kind of a constructivist approach, a variety of classroom discourse is needed, including teacher-facilitated dialogue.

2.1 Importance of argumentation in science education

Osborne (2012) asserts that learning occurs as a result of interactions between four elements: the real world, data, models, and predictions. Instructional design that allows students to freely move back and forth between these four aspects would result in rich, conceptually-linked learning that is grounded in students' experiences and ideas. In order to design such instruction, students'

voices need to be welcome in the classroom, to afford them the opportunity to engage in genuine argumentation. Osborne places much importance on the skill of argumentation, as it allows learners to hear what others have to say, and then compare and contrast those ideas with their own experiences, predictions, and mental models. Thus, throughout the process of argumentation, there is a constant interplay between the aforementioned four elements of learning. The process of argumentation in the classroom essentially mirrors that which scientists use when investigating new claims and discussing findings with colleagues. Chen and Steenhoek (2014) describe argumentation as a process that involves several stages, including participating in cooperative investigations, defending arguments, and engaging in self-reflection. The dialogic, collaborative process of argumentation can be contrasted with the closed, fixed process of explanation. Research has revealed that the predominate mode of communication used in the classroom aligns more with the latter, as opposed to genuine argumentation (Osborne, 2010). By opening up space for students to become active participants in the construction of scientific knowledge, teachers can foster students' development of the skill of argumentation. Mercer (2009) argues that building this skill should be one of the primary goals of education. Developing dialogic argumentation skills has furthermore been linked with greater conceptual learning (Osborne, 2010) and aiding in cognitive development (Duschl & Osborne, 2002). Based on these merits, supporting student argumentation should be pursued as a goal in science education across all levels.

Argumentation has been recognized as an essential learning goal not only by researchers but also by governmental and educational agencies, as evidenced by the inclusion of argumentation among the target goals of the Next Generation Science Standards recently implemented in the United States (McNiell et. al, 2016). For example, "engaging in argument from evidence" is listed as a core Science and Engineering Practice in the NGSS, and many content-specific standards are phrased as "construct an argument supported by evidence for..." (NGSS Lead States, 2013). Other countries including Finland

have also made a shift towards supporting argumentation in their national curricula. As stated in the Finnish national core curriculum for basic education 2014, “pupils are guided to use information independently and in interaction with others for problem-solving, argumentation, reasoning, drawing of conclusions, and invention” (Finnish National Agency for Education, 2016, section 3.3). By shifting the focus away from simply covering content and towards scientific literacy, progressive national curriculum documents have created more room for educators to engage students in meaningful learning that incorporates science practices, including argumentation.

While it is important to have support at the curriculum level for the development of argumentation skills, the majority of the responsibility still lies with individual schools and individual teachers to carry this out (Mercer, 2009). In order for true, open argumentation to take place, all participants must have an equal voice and the same level of opportunities to contribute to discussion, which is not possible in traditional, authoritative classrooms. On the contrary, the norms of communication in authoritative classrooms do much to stifle argumentation. Thus, a dialogic approach is more appropriate to support argumentation in teacher-led discussions (Lehesvuori et al., 2013).

Both teachers and students have been the focus of research regarding the ability to assess and engage in argumentation, and McNeill et al. (2016) report that teachers may focus on superficial surface features of talk, such as key words or phrases, to assess the quality of argumentation, rather than considering the dialogic aspects of talk or the structural components of argumentation. If students’ focus in developing arguments is fixated on following the teacher’s directions, superficial aspects of argumentation are highlighted and the resulting “pseudoargumentation” is lacking in depth and structure. Watson, Swain, and McRobbie (2004) analyzed discussions in small student groups during practical scientific inquiries and found that students infrequently constructed arguments, and the overall quality of argumentation was low. The quality of argumentation can be assessed in various ways, but in general, arguments that are more complex would include data, warrants,

rebuttals, and/or backings. Arguments that consist of a combination of several of these elements are considered to be instances of high-quality argumentation (Erduran, Simon, & Osborne, 2004). The lack of high-quality argumentation in instruction is attributed to multiple factors, including a lack of teachers' pedagogical ability to intervene and support student dialogue (Watson et al., 2004). Thus, if dialogic argumentation is not emphasized and directly supported by teachers, students can be expected to possess low skills in this area.

2.2 Communicative approaches

Even if teachers are unaware of it, patterns of classroom discourse emerge over time, creating clear expectations and norms that inform students about ideas such as who is expected to talk, whose ideas are valued, and with whom authority lies. Teachers and students are both very strongly conditioned to the classroom and are used to classic triadic patterns of discourse, where the teacher initiates discussion, students respond, and the teacher evaluates the response (Hayes & Matusov, 2005, Mortimer & Scott, 2003). Although this type of discourse typically dominates traditional authoritative classrooms, there is an array of communicative approaches that teachers can employ during the course of a lesson. Mortimer and Scott (2003) identify four classes of communicative approach, defined by characterizing classroom talk in two dimensions: dialogic-authoritative and interactive-noninteractive. The dialogic-authoritative dimension analyzes whether or not discourse is open to multiple points of view, and the interactive-noninteractive dimension refers to whether or not more than one participant is invited to engage in discourse. While at first glance these two dimensions may seem rather similar, they are independent of each other. For example, non-interactive dialogic discourse occurs when a speaker individually engages (non-interactively) in dialogic discourse by speaking from multiple points of view and acting as a real, 'unfinalized' person (Bakhtin & Emerson, 1999, in Hayes & Matusov, 2005, p. 339). Authoritative

discourse can be interactive, if for example, a teacher engages students in an interactive questioning routine in which closed questions are asked and evaluated by the teacher.

Teachers should ideally draw from a full repertoire of communicative approaches, utilizing both dialogic and authoritative approaches in ways that allow for different types of interaction, dependent upon teaching purposes and intended learning outcomes (Nurkka, Viiri, Littleton, & Lehesvuori, 2014). Authoritativeness and dialogicity can act as a “seed for their opposite pole” (Scott, Mortimer, & Aguiar, 2006, p. 623), with a dialogic exchange setting the stage for a more authoritative resolution of the topic, and vice versa. Rather than viewing classroom discourse as a random process that unfolds moment-by-moment, authoritative discourse can be used deliberately to “open up” a topic, leading to further dialogic exploration, finally followed by more authoritative discourse to “close down” an idea (Scott & Ametller, 2007). These changes in communicative approaches signal the intentional shift of teaching purposes (Lehesvuori et al., 2013). In a study regarding Finnish physics students’ growth on conceptual learning of Newton’s Third Law, teachers who used a greater variety of discourse types demonstrated greater growth in student scores on selected items of the Force Concept Inventory test (Nurkka, Mäkynen, Viiri, Savinainen, & Nieminen, 2012). While both authoritative and dialogic discourse have their rightful place within a teaching sequence, the predominant tendency for high school science teachers to use an authoritative presentation format (Lehesvuori, Ramnarain, & Viiri, 2017b; Osborne, 2010) creates a distinct need to place more focus onto better understanding dialogic discourse and how it can be supported in the classroom.

2.3 Classroom discourse and notions of authority

The fact that authoritative explanation and “short exchanges directed by the teacher” (Hayes & Matusov, 2005, p. 340) are the dominant forms of discourse used by an overwhelming majority of science teachers sheds some insight into

teacher beliefs about what type of role they play in the classroom. Science teachers can be described as actors, staging a performance (Scott et al., 2006) with a central “rhetorical project . . . to establish the consensually-agreed scientific world-view” (Duschl & Osborne, 2002). Donnelly, McGarr, & O'Reilly (2014) found that teachers exert significant power over students even in inquiry-based science lessons, using power techniques including surveillance, maintaining ownership of ideas, defining norms, and using persuasive discourse. When viewing themselves as the expert in the learning community, teachers exert tight control over classroom discourse and retain their authority to evaluate ideas without question. In his experiences working with young children in a classroom, Matusov (2001) describes feelings of frustration when “children controlled the communication” and “redefined the activity” (p. 167-168). Especially when teachers feel the need to convey correctness and focus solely on the scientific perspective, authoritative discourse is the preferred mode of communication (Lehesvuori et al., 2017b). Thus, moving from authoritative to dialogic forms of discourse represents not only a change in methods of interaction, but also necessitates a paradigm shift on the part of the teacher in terms of motivations, values, and goals. As engaging in true dialogue involves an alignment of goals between speakers (Hayes & Matusov, 2005), a teacher must be willing to relinquish a measure of control and authority in order to facilitate dialogic classroom talk. Based on observations of high school physics teachers, Lehesvuori et al. (2017b) recognize several dialogic indicators including sharing responsibility, decreasing subject authority, and explicit recognition and authentic interest in learners’ ideas. These three dialogic indicators all symbolize a shift of authority and power from the teacher to the students.

In addition to a change in motivations and teacher beliefs, promoting dialogue in the classroom necessitates radical shifts in classroom practices, norms, and structure. Scott et al. (2006) refer to the science teacher as an actor following a script, and selected instances in which teachers act “in or out of character” can be informative of teachers’ beliefs and motivations. Hayes and

Matusov (2005) argue that it is perhaps “impossible to use traditional institutional practices focused on decontextualized knowledge to promote a dialogue” (p. 340). In essence, in order for teachers to effectively promote dialogue, they must reconceive their notions of how authority is present in the classroom and adapt their modes of interaction accordingly. Giving space for students to step forward and be active participants in the construction of knowledge inherently necessitates that the teacher steps back to create room for others. The notion of the teacher as an actor is still very fitting in this case, as the teacher may choose to play a variety of roles in order to foster active participation. Rich dialogue that includes high interanimation of ideas, meaning that active comparison is made between competing claims (Scott et al., 2006), would be very unlikely if the teacher is expected to always play the role of the expert in dispensing knowledge. Instead, if a teacher is willing to reverse the power dynamic and allow students to have an authoritative voice in terms of their ideas and knowledge, rich dialogic argumentation could be more attainable.

2.4 Teacher questioning roles

Mortimer and Scott’s communicative approach framework situates classroom discourse into one of four categories: Dialogic/Interactive, Dialogic/Noninteractive, Authoritative/Interactive, and Authoritative/Noninteractive. These categories describe communication as a whole in the classroom and offer a very useful analytical tool for describing the phenomenon of communication in the classroom. However, in the author’s opinion, these communicative approaches focus mostly on the outcome of instruction and fail to describe what types of actions a teacher takes in order to achieve a desired type of classroom discourse. A teacher-centered analytical framework of similar quality could be useful in analyzing teacher’s actions when guiding and facilitating discourse.

Chen et al. (2017) reconceptualize Mortimer and Scott's model and categorize discourse based on who has ownership of ideas and who has ownership of the interactions. Chen et al. seemingly go one step further than Mortimer and Scott in interpreting the interactive component of discourse, and rather than simply classifying communication as interactive or noninteractive, their framework recognizes whether it is the teacher or the students who have control over communicative interactions. Interactive communication is clarified further in this framework, dependent upon who maintains control over the communication. Since the teacher is ultimately the head of the classroom and responsible for facilitating different types of discourse, four discrete teacher roles emerge as a result of this classification system, which are identified in Figure 1 as dispenser, moderator, coach, and participant.

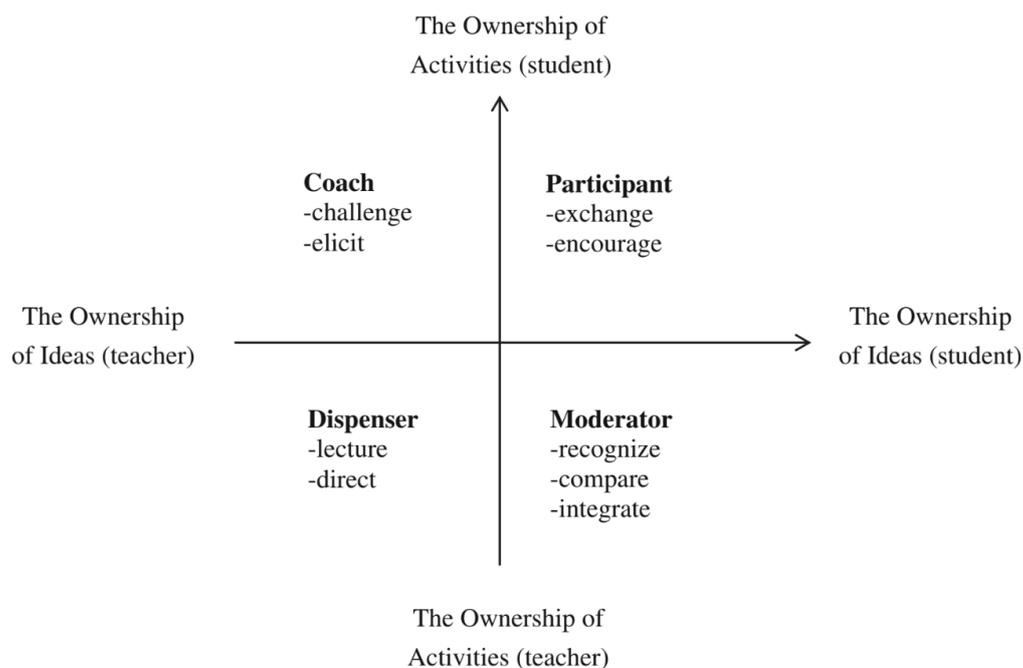


Figure 1: **Conceptual framework describing teacher questioning roles (from Chen et al., 2017)**

In this framework, teachers can retain complete power and authority over ideas and activities in the dispenser role, or grant that ownership completely to students by taking on the role of participant. The role of moderator entails recognizing students' ideas, sequencing concepts, and synthesizing discourse in a sort of "verbal jigsaw" (Chin, 2007, in Chen et al., 2017, p. 390). In the role of coach, a teacher challenges students' ideas and discourse centers on the

teacher's ideas, but students lead the conversation and contribute in turn as they see fit. The role of the coach enables a teacher to inject his or her own ideas into discussion without taking the absolute authoritative role of dispenser. An appropriate metaphor can be easily drawn from football, in which the coach is seen as a valuable asset and mentor, but the athletes nevertheless retain control over the play on the field while taking the coach's ideas into consideration.

While there are similarities between the frameworks describing communicative approaches and teacher questioning roles, identification of the roles that teachers play offers a more specific, concrete way of analyzing teacher's actions. The teacher questioning roles framework also differentiates between interactive dialogue that is teacher-led (moderator) and student-led (participant). This distinction is not present in Mortimer and Scott's model, but recognizes a fundamental difference in how discourse can be carried out.

The teacher questioning roles framework was developed to describe classroom interactions in primary school science lessons, but could be a promising tool to use in analyzing discourse across many grade levels. Initial findings suggest that a greater variety of teacher questioning roles supports higher-level student cognitive responses (Chen et al., 2017). The role of dispenser was found to be the most common teacher questioning role in teachers beginning a professional development program aimed at designing argument-based inquiry instruction. After participation in four years of ongoing professional development, teachers utilized a greater variety of questioning roles and used increased amounts of student-centered questioning roles such as moderator and coach. One questioning role is not necessarily seen as superior to any of the other roles, but instead an emphasis is placed on increasing the variety of questioning roles used by teachers. In support of this, Chen et al. found that a greater variety of questioning roles coincided with higher levels of cognitive responses from students. A resultant teaching rhythm can then be established, consisting of alternating periods of student-centered and teacher-centered discourse, similar to that seen in cumulative communication structures (Lehesvuori et al., 2013).

2.5 Pedagogical link-making

The shared experiences of teachers and students provide fertile ground upon which a rich, interconnected web of ideas can grow. Although the cognitive task of making conceptual links is performed independently by individual students, a central role that teachers play is facilitating the link-making process. It is a key responsibility of teachers to make explicit conceptual links available to students and to afford them the opportunity to spend time thinking, processing, and making sense of them in their own unique way (Scott et al., 2011). Making conceptual links is a key tenet of constructivist learning theory, and the ability to create a cohesive narrative is an essential part of the learning process. Scott et al. (2011) identify three forms of pedagogical link-making: 1) to support knowledge building, 2) to promote continuity, and 3) to encourage emotional engagement.

Firstly, teachers can make pedagogical links to support knowledge building by making connections between different kinds of knowledge. This includes making links between scientific and everyday concepts, identifying links between scientific concepts, and making links between science and real-world phenomena. Pedagogical link-making to support knowledge building can also be done by using multiple representations of the same scientific phenomena, relating different scales and levels of explanation (i.e. moving between macro- and microscopic models), and the use of analogies. Although this link-making can be accomplished to some extent by the authoritative presentation of knowledge in the role of dispenser, input and participation on the behalf of students is also required in order to ground the concepts within prior knowledge, and therefore can best be accomplished through the more interactive and dialogic roles of moderator and coach.

The second key task of pedagogical link-making concerns promoting continuity by connecting learning events that occur along different points in time. By pointing out comparisons and interrelationships between different learning events, a teacher develops the scientific story and creates relevance for

new learning tasks. By seeking to maintain the flow of conversation and creating connections between episodes, a teacher can create cumulativeness on not only the short-term scale (Lehesvuori et al., 2013), but also create a more cohesive narrative on the long-term. Teachers play a significant role in this process by explicitly creating links to relate what was previously being done in the classroom to what will happen next. The teacher questioning role of moderator would facilitate this process, as the teacher weaves together a narrative consisting of multiple student voices and experiences.

The third form of pedagogical link-making identified by Scott et al. (2011) concerns making links in order to promote positive emotional engagement. This is accomplished by displaying genuine interest in students' ideas and addressing substantive content brought up by students. An example of this could be personalizing a student's idea by affixing their name to the concept, so that a student's idea is addressed in reference to their name. Encouraging emotional engagement also involves making links between science content and things that have relevance in students' lives, as well as intellectual relevance, which is exemplified in getting students invested in making and justifying a prediction. Making positive emotional links with learning also encompasses more generic positive emotional support, which is not to be overlooked despite the criticism that generic praise can be detrimental to student performance (Mueller & Dweck, 1998). By showing true interest in students' ideas and displaying genuine emotional investment, teachers can positively affect learner motivation and promote their engagement with substantive content. This can be accomplished when a teacher plays the role of participant, in which the teacher's main tasks are to encourage student exchange of ideas, critical thinking, and create more "space of learning" (Marton & Tsui, 2004, in Chen et al., 2017). Furthermore, by being open to student ideas, a teacher opens the door to dialogue, which can support other forms of pedagogical link-making.

A mutual theme that ties all of the forms of pedagogical link-making together is that they all share the same goal of producing an interconnected, student-centered web of conceptual learning. What is important is not that a

teacher covers the content, but that learners have the opportunity to make their own sense of it and connect with it. Implementing all three types of pedagogical link-making demands a great deal of expertise from a teacher, requiring them to have and utilize deep insights regarding the content, students' prior knowledge, and students' emotional engagement. This also requires teachers to draw from a broad repertoire of questioning roles and utilize a variety of communicative approaches in their teaching.

2.6 Supports of dialogicity and argumentation

As described previously, Lehesvuori et al. (2017b) identify several dialogic indicators that, when present, serve as supports for classroom dialogue and, thus, argumentation. In contrast with teacher-centered authoritative indicators, which include evaluative feedback, excluding learners from science, and conveying correctness, the dialogic indicators symbolize a shift of power and authority from the teacher to the students. In addition to the aforementioned dialogic indicators (sharing responsibility, decreasing subject authority, and explicit acknowledgement of learner ideas), Lehesvuori et al. (2017b) also characterize the following as dialogic indicators: proxemic shift towards learners, neutral repetition, and rising intonation and wait time. These dialogic indicators show that the teacher invites students to participate in dialogue by the intentional use of space, verbal cues, and temporal elements.

Kim and Hand (2015) summarized common characteristics of primary school teachers who were able to support a high level of argumentation in their students. Similar to practices that Scott et al. (2011) describe as supporting pedagogical link-making, these high-level teachers elicit reasoning from students, challenge students to come up with their own answers, and "facilitate conversation between students in a way that enabled them to use evidence and experience" (p. 234). Without question, these teacher habits contain dialogic indicators and would fit within the roles of moderator, coach, or participant.

Achieving the use of dialogic indicators into teaching cannot necessarily be approached as simply following a predefined strategy. Instead, pursuing dialogic classroom discourse that supports argumentation involves a change in motivation and goals, and affects what types of roles a teacher plays in the classroom. The use of dialogic practices can seem rather counterintuitive, and Hayes and Matusov (2005) state that teachers “must consciously resist institutionally defined ‘teacher talk’” (p. 341) in order to achieve dialogue. In addition to these challenges that teachers face when trying to implement dialogic practices, Nurkka et al. (2012) found that teachers feel less comfortable using a greater variety of discourse in content areas that they are less familiar with.

In light of these challenges and the predominance of authoritative teaching practices in the science classroom, a focus on dialogic teaching roles is certainly apropos. Through further research, a distinction could be made between true dialogue and discourse that contains some superficial features of dialogic discourse, but is lacking in authenticity, openness, or genuineness. Specifically, close, micro-scale analysis into features of discourse that help to facilitate argumentation could be useful in more clearly defining effective practices that support high quality argumentative discourse in the science classroom.

3 RESEARCH QUESTIONS

This study endeavors to examine discourse on multiple levels, to describe how student argumentation can be supported by the use of different communicative approaches and teacher questioning roles. On the basis of the literature introduced in chapter 2, the following research questions (RQ) were used to drive the present study.

1. What types of roles do teachers play when aiming to facilitate student dialogue and argumentation?

2. How are communicative approaches and teacher questioning roles related?
3. What communicative strategies are effective at facilitating student argumentation?
4. What unique tactics do teachers use when playing various teacher questioning roles?

4 METHODOLOGY

In light of the research questions presented in chapter 3, this study was designed with the intention of analyzing classroom discourse from several perspectives. The theoretical models outlined in chapter 2 were utilized to describe specific aspects of communication and interactions such as communicative approach and student argumentation level. By having a broad focus and using more than one theoretical framework, a more holistic overview of classroom discourse was created. The research methodology, as described in this chapter, included several rounds of discourse analysis of recorded video data from lower secondary classrooms in Finland. As explained in this chapter, steps were taken to ensure the reliability of analysis, including the use of a coding manual and collaboration with other researchers.

4.1 Research design

Argumentation is central to the process of learning science, and Osborne (2010) calls for the need to understand what types of learning environments support argumentation. As dialogic discourse has been shown to support argumentation (Duschl & Osborne, 2002), further attention is due to understanding factors that contribute to dialogicity in the science classroom. The present study focused on recognizing discourse within a chain of communication (Scott et al., 2006) as well as including smaller critical details that provide insight into teachers' beliefs and motivations regarding ownership

over dialogue and classroom activities. Mortimer and Scott's framework of communicative approaches was used to classify discourse in a broader lens, and Chen et al.'s teacher questioning roles were used to draw a bit closer to teachers' habits and common practices. In coding video transcripts, efforts were made to capture both the historical aspects as well as the dynamic aspects of discourse (Mercer, 2007). Multi-level analysis of video data from two lower secondary physics classes in Finland was used in order to accurately depict the nature of discourse occurring in these settings. Multi-level qualitative analysis is defended by Lehesvuori et al. (2013) as follows:

Nevertheless, although recognizing structures and describing communication are important in providing an overall view of teaching, in order to capture the essence of classroom communications as they appear to the teacher and students, more micro-scale, moment-by-moment, exploration has a key place in classroom communication research. (p. 935)

By taking a close look at classroom discourse, we can begin to understand language as a cultural tool in the science classroom, and recognize "communication, thinking and learning as related processes which are shaped by culture" (Mercer, 2007, p. 138).

4.2 Data collection

Video data of lessons was collected as part of an ongoing research project at the University of Jyväskylä funded by the Academy of Finland (project number 286576) and the Finnish Cultural Foundation (fund number 00160353). The project consists of an ongoing 2-year professional development program targeting dialogicity and argumentation practices in math and science classrooms in Finnish lower-secondary schools. Lessons were designed with teacher input, and a total of six teachers from different schools participated in the project. At the beginning of the PD program, considerable variation existed among the teachers concerning their awareness of dialogicity, and lessons

showed varying levels of dialogicity in practice (Lehesvuori et al., 2017b). During the first year of the project, from which the video data for this study is taken, researchers focused on helping teachers to develop dialogic practices through planning sessions and reflective discussions after implementation of lessons. Teachers implemented the lessons and each lesson was video recorded. The audio from each lesson was then transcribed to aid in analysis. Both students' and teachers' names were replaced with Western pseudonyms corresponding to the gender of individuals in an effort to retain anonymity.

Two lessons from two teachers each were used for analysis, for a total of four lessons, totaling in roughly 180 minutes of classroom video. These two teachers taught in different schools in the same city. While some demographic differences may exist between these two student populations, the context was relatively similar, as both classes were grade seven physics at a Finnish public school. One consideration to be noted is that the lessons taught by the first teacher (Jim) were approximately 40 minutes in length, while Don's lessons ranged from 45 minutes to 55 minutes. Thus, Jim's lessons may have been slightly affected by time constraints, influencing the type of discourse present in his teaching. The whole-class transcripts included annotations from audio recorded by a lapel microphone that the teacher wore throughout the course of the entire lesson. Audio from students was included in the transcription whenever talking directly to the teacher or to the group as a whole. Thus, the transcripts offer a picture of classroom discourse from the point of view of the teacher, and do not include small group conversations that the teacher was not a part of. Nonverbal annotations were also added to the transcript, which included observations such as classroom layout, eye contact, teacher position, and gestures.

The first lesson used in this study, referred to hereafter as Lesson 1, focused on supporting dialogicity and argumentation using a group task given to the students. This argumentation task, which is included in Appendix B, presented students with a situation in which three individuals (persons A, B, and C) are seated in front of a mirror at a distance of approximately 0.5 meters

away. The mirror is centered in front of person B, and is wide enough to extend barely beyond person B's shoulders. In other words, the mirror does not extend far enough to be directly in front of persons A and C as they sit facing across the table. The students were then supplied with 4 statements (choices A-D), which they were to evaluate. Students were asked to choose one statement which they thought was correct and defend their reasoning for that choice. Thus, the topic of the task centered on how light interacts with a mirror and how images are formed in a mirror. Specifically, students had to defend their own ideas about the relationship between the positioning of objects, an observer, and an image generated in a mirror. In a true dialogic fashion, two of the supplied choices (B and D) were correct, but this was not told to the students.

The second lesson (referred to as Lesson 2) was taught by the same teachers several weeks after the first lesson. Lesson 2 is also represented in more detail in Appendix B. In this lesson, groups of students were presented with one of four temperature/time graphs, and asked to decide whether or not the graph accurately depicted how the temperature of water changes as water melts from ice to steam. Students were also supplied with twelve fact cards, all of which contained true statements. The argumentation task presented to students involved using the fact cards to defend their claim about the quality of their graph.

While each lesson ranged in length from 45 to 55 minutes, the analysis and coding of classroom discourse focused exclusively on whole-class discussions, which took place at the end of each lesson. Each lesson followed a similar sequence, starting with a whole-class introduction to the activity, after which students were given time to work on a task in small groups. This was concluded by a whole-class discussion. Since the goal of these whole-class discussions was to give students an opportunity to share ideas and build consensus, these sections of discourse were of the greatest interest for this study. These whole-class discussions ranged in length from 10 minutes (Jim) to 20-25 minutes (Don).

4.3 Analysis

In this study, analysis of transcribed video data followed several steps, as summarized in Table 1. The analysis started with general observations and moved into more specific coding and discourse analysis. Each stage of analysis aimed to inform one or more of the research questions described in chapter 3.

Table 1: **Stages of analysis and analytical methods used**

Stage	Method of analysis	Aims
1	Open coding	Familiarization with content
2	Content analysis: communicative approaches	Background, RQ 2 & 3
3	Content analysis: teacher roles	RQ 1 & 2
4	Content analysis: student argumentation levels	RQ 1 & 3
5	Microanalysis	RQ 2 & 4

4.3.1 Open coding and communicative approaches

Initially, open coding of discourse was used to gain a sense of familiarity with the data and to decide how to move forward with the help of open notes and observations. Upon completion and review of the open coding, the first round of content analysis was carried out using a pre-defined coding scheme based on the communicative approaches framework (Mortimer & Scott, 2003). Since the concept of communicative approach applies to extended exchanges of communication between teachers and students, each episode of conversation was considered a unit of analysis. Individual episodes of conversation were determined based on the content of talk, as well as shifts in communicative approach. Using this definition to distinguish when one conversation episode began and when another ended proved to be quite problematic, so this level of coding was used only to make general qualitative assessments about the nature of discourse at various points in time during the lessons. This level of coding was not intended to draw comparisons between teachers regarding the frequency of use of communicative approaches, but simply to identify at which

points in the lesson certain communicative approaches were used. More detailed explanations of coding protocol are included in Appendix A.

4.3.2 Teacher questioning roles

The third round of coding focused on teacher questioning roles (Chen et al., 2017). In order to capture the moment-by-moment nature of talk in the classroom, each utterance by the teacher was used as the unit of analysis. Context was critical in assigning teacher questioning roles to individual utterances, and an effort was made to use not only the verbal content of discourse, but also non-verbal cues and other visual indicators when interpreting what type of role the teacher was playing. Only relevant sections of discourse were coded, but there were also instances of talk not related to content embedded within instruction. These instances that served little pedagogical purpose were coded as irrelevant. Examples of off-topic talk that was disregarded include teachers trouble-shooting technical difficulties with devices, classroom discipline, procedural issues, and unrelated social talk.

One methodological issue that was encountered when determining teacher roles involved coding whole-group discussions in which the teacher was silent. The unit of analysis for this round of coding consisted of teacher utterances, but periods in which the teacher remained silent and allowed students to speak contained no teacher utterances to code. After the first round of open coding, intentional teacher silence was observed to have a considerable influence on classroom discourse, and it was deemed appropriate to consider certain noticeable periods of teacher silence as instances of the role of participant. As discussed in chapter 2.3, when teachers play this role they hand the ownership of both the ideas and the activity over to students. Thus, select instances in which the teacher abstained from speaking altogether were coded as participant, although this coding convention is absent in the original teacher questioning roles framework developed by Chen et al. (2017). Teacher silence during discourse is elsewhere elicited as a theme by Kosko, Rougee, and Herbst (2014) in their study describing the expectations that mathematics teachers hold

regarding actions which support argumentative discourse. However, appropriate conventions for coding instances of teacher silence during classroom discourse are not well-established, and the coding methodology in this study was adapted in a unique way.

4.3.3 Student argumentation levels

The fourth round of coding focused on student argumentation levels, in order to determine student responses to various types of communicative strategies used by teachers, as well as to assess the degree to which teachers achieved the goal of facilitating student argumentation. One method of assessing the quality of arguments involves deconstructing arguments into their components of Toulmin's argument pattern (TAP), which include claims, warrants, data, rebuttals, and backing. The general principle underlying this is that the greater the number of types of argument components, the more complex the argument, and therefore, the higher the argumentation quality (Erduran et al., 2004). Another scheme for assessing argumentation quality involves focusing on the presence or absence of rebuttals. As Erduran et al. (2004) write:

Only arguments which rebut these components of argument can ever undermine the belief of another. Oppositional episodes without rebuttals, therefore, have the potential to continue forever with no change of mind or evaluation of the quality of the substance of an argument. Thus, arguments with rebuttals, we believe, are an essential element of better quality arguments and demonstrate a higher level capability with argumentation. (p. 927)

As shown in Table 2, by focusing on the presence or absence of rebuttals, Erduran et al. (2004) classified arguments on a scale from Level 1 to 5, with Level 1 argumentation consisting of very basic argumentation, and Level 5 argumentation consisting of complex, extended argumentation with more than one rebuttal. Due to its concise nature, this classification scheme was chosen for the present study as an efficient means of gauging student argumentation.

Table 2: Analytical framework used for assessing the quality of argumentation (from Erduran et al., 2004, p. 928)

Level 1	Level 1 argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim.
Level 2	Level 2 argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals.
Level 3	Level 3 argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal.
Level 4	Level 4 argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.
Level 5	Level 5 argumentation displays an extended argument with more than one rebuttal.

4.3.4 Microanalysis

The final element of analysis in the present study involved more detailed microanalysis to not only gain a sense of what was being said, but how it was said, focusing on the “functional and sense-making properties of language” (Wooffitt, 2005). Episodes of interest for this microanalysis included instances where students engaged in high-quality complex argumentation, as well as instances where teachers were unable to facilitate productive argumentative dialogue. Episodes were selected to exemplify noteworthy patterns of discourse recognized by the author. These portions of the transcript were translated by the author from Finnish into English and proofread by a native Finnish speaker for inclusion in the final text, to provide concrete examples of these instances.

The process of translating classroom talk from Finnish to English proved to be challenging, as there are substantial differences in certain verb tenses, idioms, and the word order in phrases. Efforts were made to stay true to the word choice of teachers and students, but in order to effectively convey the substance of conversations, slight adjustments had to be made in the English text. In several instances, extra information (such as referring to statement C and person D as “statement C and person D”, rather than simply “C and D”)

was added to the transcript to add context for the reader, as the points of reference which were available in the classroom are unavailable in a transcript. The main goal in translating the transcript was to supply the reader with coherent examples of classroom discourse. This was achieved by slightly modifying the dialogue and inserting contextual notes as needed.

The microanalysis involved looking for finer details of interactions that are not represented by simplifying the transcripts into a series of alphanumeric codes. The main aim was to draw out subtle nuances, tactics, and habits that teachers draw on, either intentionally or unintentionally. Cues from the video were used in this stage and teachers' motivations were interpreted based on not only what they said, but also their posture, positioning in the classroom, and nonverbal interactions with students. These communicative acts were considered in light of the overall communicative approach and teacher roles to paint a detailed picture of the actions and motivations within classroom discourse.

4.4 Reliability of coding

In order to assess the reliability of coding, approximately twenty percent of the video data was examined and coded by a second coder to examine teacher questioning roles and communicative approaches. The second coder is a postdoctoral researcher at the University of Jyväskylä and is a member of the research group conducting the original project from which the video data for this study is derived. As this study's unit of analysis for teacher questioning roles was very clearly defined, a statistical test (Cohen's kappa) was used to determine the level of agreement between coders for coding of teacher questioning roles.

To clarify the use of the teacher questioning roles scale, a coding manual was developed based on the framework (see Appendix A). This coding manual was produced during the coding process and modified as necessary in order to clarify how to categorize discourse. Inconsistencies in the coding manual were

discussed by the two coders in an effort to reach a consensus regarding the use of the scales. Since the coding manual was a working document, it was expected that some variation existed between interpretations made during the first stages of coding and those observations recorded in the final phases of coding. Thus, both coders completed a second round of coding after discussion and revision of the coding manual.

After the first round of coding, Cohen's κ was calculated to determine the level of agreement between the two coders for categorization of teacher questioning roles for a data set of 74 teacher utterances, which represented approximately 20% of the data set. The test revealed moderate agreement between the two coders $\kappa = .524, p < .0005$. As discussed by Sim and Wright (2005), Cohen's κ values that range from .41 to .60 represent moderate agreement, while κ values between .61 and .80 represent substantial agreement between coders. Since the teacher questioning roles scale was relatively new to both coders, some variation was expected, but a κ value closer to 0.7 was preferred. Further analysis of the coding comparison data revealed a 64.9% agreement between coders. Disagreements in coding were discussed and used to further clarify the coding manual.

A second round of coding was then performed by both coders after refining and clarifying procedural issues in the coding manual. Although this revision process could have lasted several more rounds to achieve an even higher level of agreement, a second round of analysis yielded a Cohen's κ value of 0.735 ($p < .0005$), which could be interpreted as substantial agreement between the two coders (Sim & Wright, 2005). The data set used for analysis in the second round included 77 teacher utterances. The sample size increased slightly during the second round because of fewer omissions of coding, which had occurred in the first round of coding. The second round of coding yielded 80.5% agreement between the coders, indicating greater reliability than the first round of coding.

Since instances of communicative approach and student argumentation level codes were relatively infrequent, the use of these scales was compared,

discussed, and revised as necessary in lieu of a statistical measure of reliability. The second coder also coded communicative approaches for each sample of the transcript, and differences in coding were noted and discussed. Another researcher with considerable experience using TAP reviewed the assessment of argumentation in this study, further increasing the trustworthiness of interpretations.

5 RESULTS

5.1 Teacher questioning roles and communicative approaches

RQ#1: What types of roles do teachers play when aiming to facilitate student dialogue and argumentation?

Both teachers used all of the four teacher questioning roles to some extent in their instruction. As these lessons were specifically designed to facilitate dialogue, it comes as no surprise that the role of moderator was the most common role in each lesson. As shown in Figure 2, both teachers used the role of moderator extensively in Lesson 2, accounting for over 50% of teacher utterances. The role of dispenser followed overall as the second most common teacher questioning role. Jim used the role of dispenser at a relative frequency of over 30%, while the role of dispenser accounted for less than 20% and 10% of Lessons 1 and 2, respectively, for Don. The relative frequency of the role of coach was comparable in each of the lessons, but Don used the role of coach as often or more often than the role of dispenser. The role of participant was the least common for both teachers, and Jim used the role of participant especially infrequently. This is exemplified in Jim's second lesson, in which the role of participant was absent altogether. It should be noted that the frequencies of each role should not be compared between different lessons, as the data set for each lesson varied in size. For reference, Jim's first and second lessons consisted of a total of 37 and 50 utterances, respectively, while Don's lessons

included 58 and 85 utterances. As noted previously, this was partially due to time constraints as the time allotted for each lesson was inconsistent.

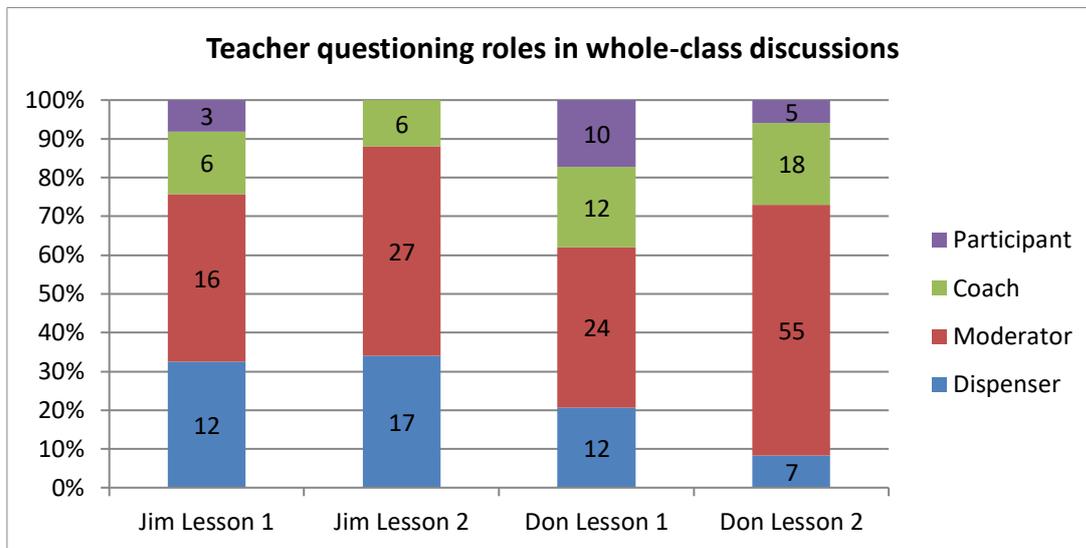


Figure 2: Relative frequencies of teacher questioning roles observed in whole-class discussions

The role of moderator was noted at times to be used as a sort of stepping stone on the way to facilitating robust conversation in the roles of coach and participant. As shown by the arrows in Figures 3 and 4, the role of moderator frequently precedes the roles of coach and participant. The role of dispenser occasionally was noted as a precursor to coach, but not as frequently as moderator. In light of these observations, a generalized rhythm of teaching can be described from these lessons. Firstly, the teacher began discourse by framing the discussion in the role of dispenser. This was often followed by the teacher collecting students' ideas in the role of moderator. After nonevaluative sharing of ideas, the stage was set for either the teacher to challenge student ideas in the coaching role, or for students to initiate argumentation while the teacher acts as a participant. For reference, this sequence is also exemplified in turns 1, 3, 5, and 9 of Table 6 in the microanalysis (chapter 5.3.1). Here, Don first collects student ideas, then presents a challenging question in the role of coach, and lastly allows students to maintain control over the conversation, playing the role of participant. A comparison can be made with this pattern and the "opening-up" phase of a cumulative communication structure (Lehesvuori et

al., 2013). This observation places the purpose of moderator as a sort of intermediate role and a necessary precursor before achieving student-led discourse in the roles of coach or participant.

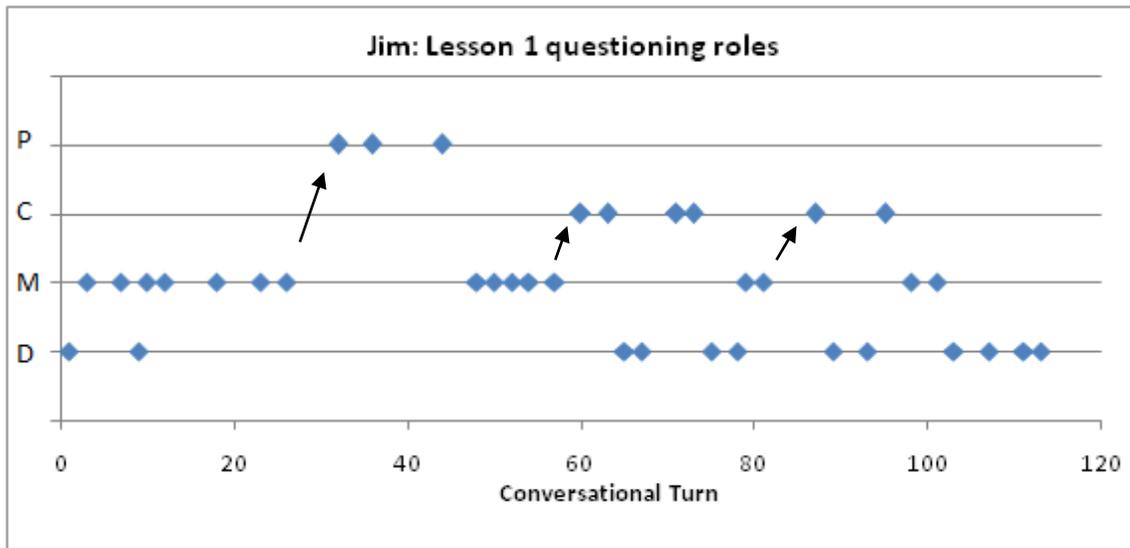


Figure 3: **Teacher questioning roles as coded in Jim: Lesson 1.** The vertical axis indicates teacher questioning roles (P=Participant, C=Coach, M=Moderator, D=Dispenser). Arrows indicate instances in which moderator precedes the role of participant or coach.

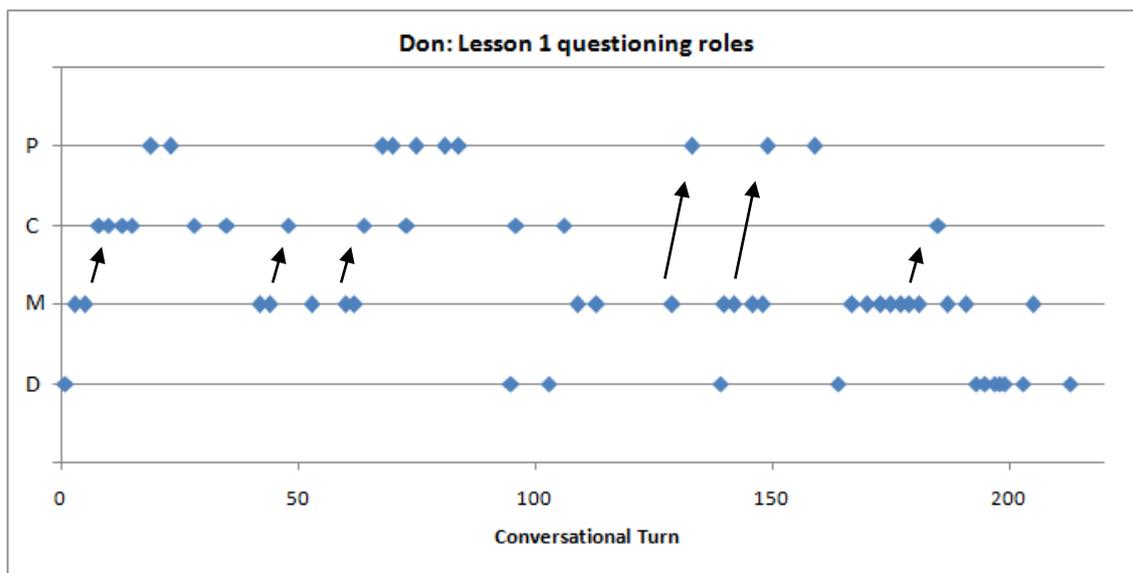


Figure 4: **Teacher questioning roles as coded in Don: Lesson 1.** For interpretation, see explanation in Figure 3.

RQ#2: How are communicative approaches and teacher questioning roles related?

Although the teacher questioning roles framework originated as a reconceptualization of Mortimer and Scott's framework of communicative approaches, substantial differences exist between the two. Both models share a similar dimension that measures who has ownership over the ideas of classroom talk, which is categorized as authoritative/dialogic in the communicative approaches framework (Mortimer & Scott, 2003), and labeled as "ownership over ideas" in the teacher questioning roles framework (Chen et al., 2017). However, the difference exists in the other dimension identified in each respective model. The communicative approaches model distinguishes between interactive and non-interactive communication, but the teacher questioning roles framework differentiates who has ownership over the interactions. Thus, some cross-over exists between the models, but they are used to measure different aspects of communication.

Investigating the relationship between these two frameworks revealed that both A/I and A/N discourse were used to play the role of dispenser. As shown in Figure 5, authoritative discourse often coincided with the role of dispenser, illustrated by discourse close to turns 1, 65, 90, and 110. By definition, as speech becomes more authoritative it revolves around the speaker's ideas, thus reinforcing the relationship between dispenser and authoritative discourse. Several instances were also noted in which the teacher used an A/I approach to carry out the role of coach, for example in Figure 5 near turns 70, 90, and 100. Coaching was also carried out using dialogic approaches, as displayed close to turn 60 in Figure 5. When playing the role of moderator, Jim predominately relied on dialogic approaches, as did Don, as shown in Figure 6. Of particular interest was the observation that the role of participant was concurrent with a D/I approach throughout the lessons, and no other communicative approach was observed in conjunction with the role of participant.

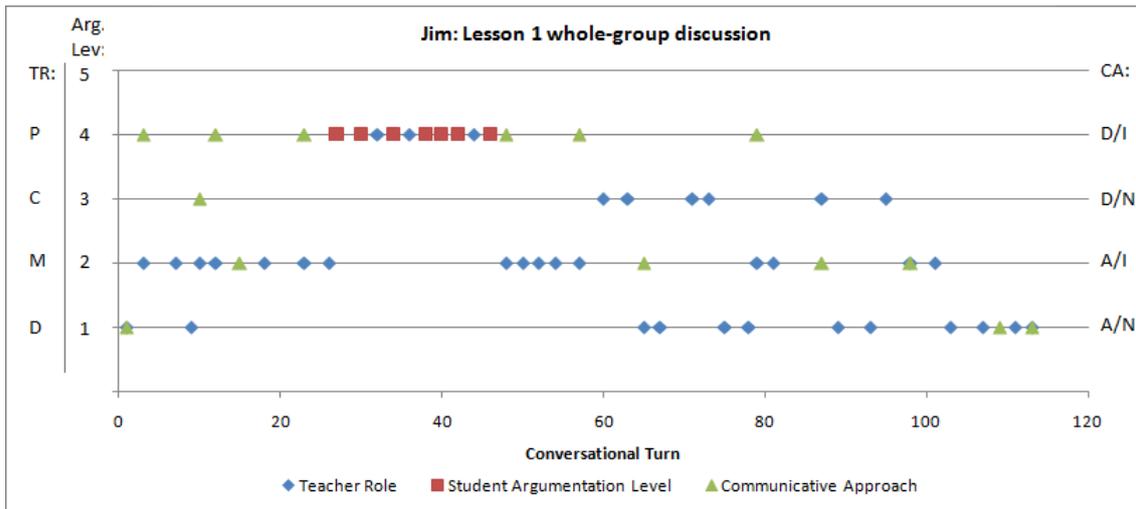


Figure 5: **Discourse from whole-group discussions as coded from Jim: Lesson 1.** The horizontal axis indicates turns in conversation. Along the vertical axis are three different scales. The first is teacher roles, represented by blue diamonds (P=Participant, C=Coach, M=Moderator, D=Dispenser). The second is student argumentation level, represented by red squares (scale of 1-5). The third is communicative approach, represented by green triangles (D/I=Dialogic/Interactive, D/N=Dialogic/Noninteractive, A/I=Authoritative/Interactive, A/N=Authoritative/Noninteractive).

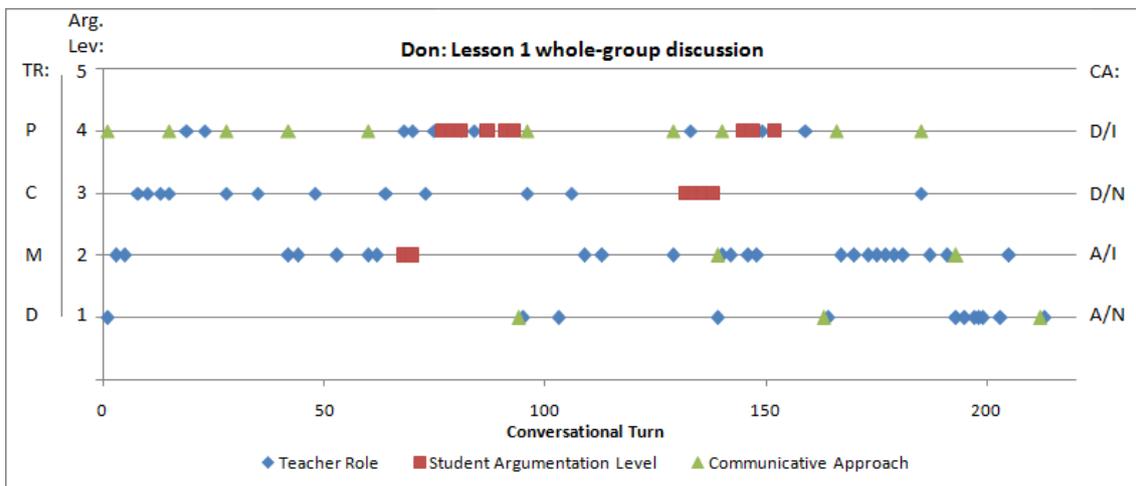


Figure 6: **Discourse from whole-group discussions as coded from Don: Lesson 1.** For interpretation, see explanation in Figure 5.

The loosely defined relationship between teacher questioning roles and communicative approaches is further exemplified in Table 3. Don shifts from moderator to the role of coach in turn 4, but retains a dialogic communicative approach. From turn 4 to turn 6, Don continues to play the role of coach, but in turn 6 briefly uses an authoritative stance during his debate with Matthew.

Thus, the role of coach is not fixed to a single communicative approach, but can be accomplished using both authoritative and dialogic discourse.

Table 3. Examples of teacher questioning roles and communicative approaches from transcript

	Classroom discourse:	Teacher Questioning Role:	CA
1	Matthew: In my opinion it doesn't support it.		
2	Don: The boys' claim.	Moderator	D/I
3	Matthew: Right.		
4	Don: Why not?	Coach	(D/I)
5	Matthew: Because, in that spot where it changes from ice to water then it supports that the graph is correct, but the question of, what happens during the time when you heat it to 100 degrees, then it doesn't show whether or not it continues with a horizontal line.		
6	Don: Well it's right there: 100 degrees.	Coach	A/I
7	Matthew: Right, but the line ends at that point		
8	Don: But could it - so, the boys claim that this is wrong, this graph. ... That graph doesn't show the situation where water is heated from ice to steam. Does this statement G support the boys' claim?	Moderator	D/I
9	Matthew: No.		
10	Don: No. Because?	Coach	(D/I)

To summarize these observations related to RQ#2, the role of dispenser was carried out using primarily authoritative communicative approaches, while the role of moderator relied on dialogic discourse. Both A/I and D/I discourse were observed in conjunction with coach, while only D/I discourse was used in role of participant. These observations are summarized in Table 4.

Table 4: Comparison of communicative approaches framework and teacher questioning roles

CA	Teacher Questioning Role			
	Dispenser	Moderator	Coach	Participant
A/N	X			
A/I	X		X	
D/N		X		
D/I		X	X	X

5.2 Student argumentation

RQ#3: What communicative strategies are effective at facilitating student argumentation?

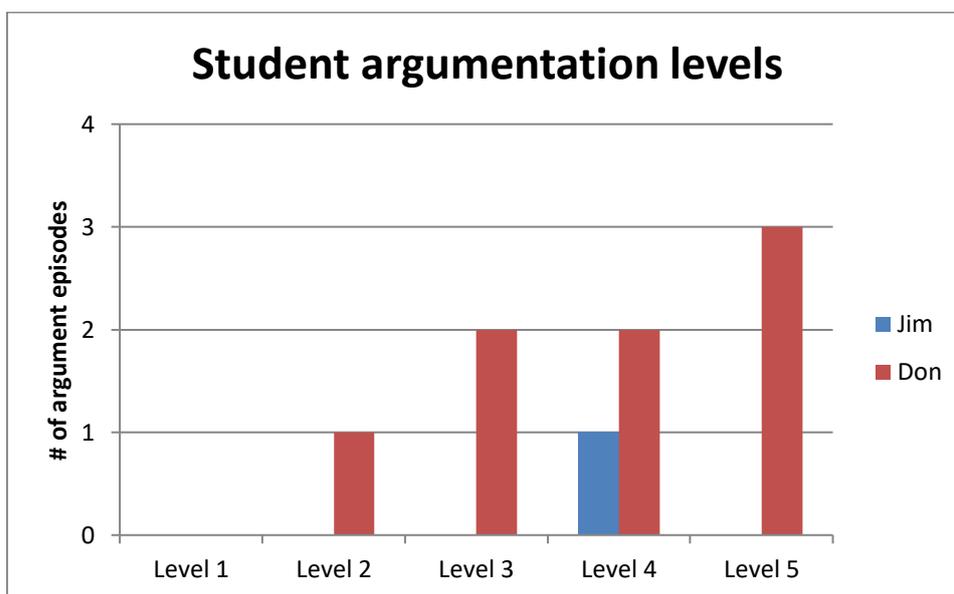


Figure 7. Observed frequency of student argumentation in lessons

In comparing the two lessons taught by Don with those taught by his counterpart, it was observed that students in Don's class engaged in argumentation more frequently than students in Jim's class. As depicted in Figure 7, Don's lessons contained seven episodes of Level 3 argumentation or higher, while only one episode of Level 4 argumentation was observed in Jim's lessons. While the sample size of this study is relatively small, on the basis of these observations it can be stated that Don succeeded in facilitating argumentation more frequently than Jim did. It comes as a pleasant surprise to

find that not only did Don's students engage in argumentation frequently, they also constructed relatively complex, high-level arguments.

As described previously in the methodology section in chapter 4, argumentation levels can be assessed by deconstructing arguments into their constituent elements, and analyzing the complexity of the argument based on the presence of components such as claims, warrants, backing, and rebuttals. Strong rebuttals are especially considered indicative of high-level argumentation, and served as a basis for assessing student argumentation levels in the discourse used for this study. Table 5 serves as an example which illustrates the process of assessing argumentation level. As shown in the argumentation notes column, the following portion of talk consists of claim (turn 1) with data and/or warrants (turns 1 & 2). This is followed by a counterclaim with a warrant (turn 3). Claims are backed up by data and/or warrants, but Matthew's counterclaim is not directly in opposition to the claim. Since turn 3 does not offer a direct rebuttal, this argumentation episode is classified as relatively weak, Level 2 argumentation. Another example of the classification of argumentation can be found in Appendix C.

Table 5. **Sample of argumentation from Don: Lesson 1.** (Note: ellipses indicated irrelevant omitted text)

	Speaker	Classroom discussion:	Argumentation notes:
1	Jacob:	[talking to group] ...William explained it to us, ... that if A looks in the mirror, then he doesn't ... see person B, because he's like looking from the side. So, ... he would see only that person C, because like the light would be coming at like a 90 degree angle and he wouldn't be able to see person B, but ..., it could definitely be possible, that he would see the other person but... if you go with choice C, that persons A and C see only each other, then yeah it probably is true.	Jacob presents a claim: "Person A can only see Person C". "The light would be coming at a 90 degree angle" can be interpreted as data, or perhaps as a warrant, if you consider that he is referring to the image as his data.
2	Michael:	[talking to group/teacher (unclear)] Yeah and we tested it a little bit, that if I look from here then I don't see towards the center, nor do I see myself.	Michael offers more data in support of the claim: "We tested it ourselves"

- So I see quite a bit of that edge, if the mirror would be right here [gesturing towards mirror at back of classroom]
- 3 Matthew: [talking at teacher] But, ... that option C could be true if every one of the people looks only at one specific spot on the mirror. [no response from teacher, shifts stance towards group] Because then the person can't see two people at the same time, when he looks precisely only at one spot.
- Matthew offers a counterclaim: "Option C could be true if everyone looks at only one specific spot on the mirror."
Warrant: "Because you can't see two people at the same time"
-

A marked difference was observed between argumentation levels in the two classes. The task remains, however, of determining why Don was successful in facilitating argumentation, while Jim's lessons were almost entirely lacking in student argumentation. In answering this question, a contrast can be drawn between the type of discourse present in Jim's second lesson (Figure 8) and Don's second lesson (Figure 9). While Jim frequently returns to the role of dispenser throughout the lesson, Don uses the role of dispenser very seldom, maintaining long stretches of more dialogic discourse alternating between moderator, coach, and participant. These more dialogic roles appear to support argumentation, while the role of dispenser excluded students from asserting their own logic and reasoning as a part of classroom discourse. Referring back to Lesson 1 (Figures 5 & 6), three episodes of high-level argumentation were observed during which the teacher played the role of participant. In these three examples, the role of moderator or coach was used immediately before the argumentation episode, while the role of participant was used to maintain the student dialogue.

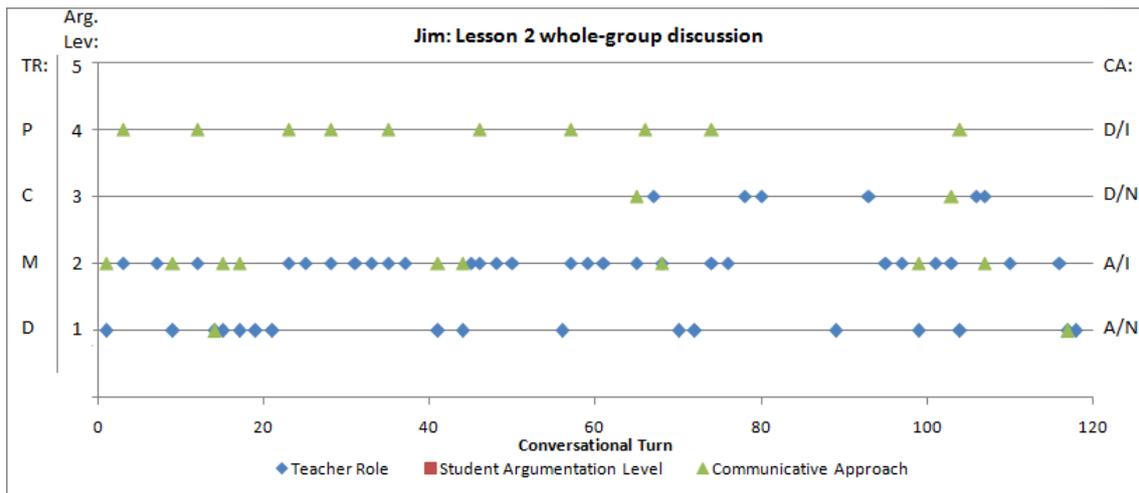


Figure 8. **Discourse from whole-group discussions as coded from Jim: Lesson 2.** The horizontal axis indicates turns in conversation. Along the vertical axis are three different scales. Teacher roles are represented by blue diamonds (P=Participant, C=Coach, M=Moderator, D=Dispenser). Student argumentation level is represented by red squares (scale of 1-5). Communicative approach is represented by green triangles (D/I=Dialogic/Interactive, D/N=Dialogic/Noninteractive, A/I=Authoritative/Interactive, A/N=Authoritative/Noninteractive).

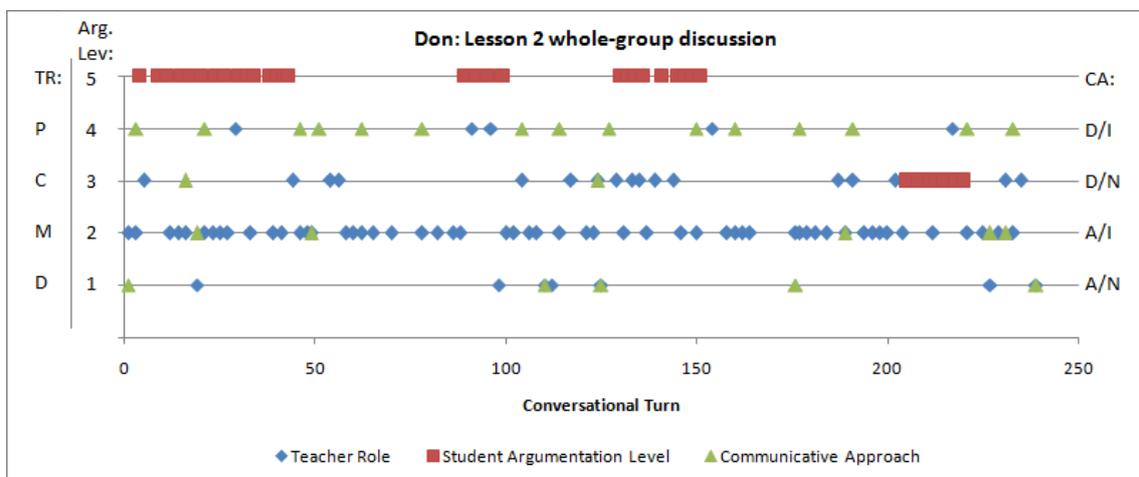


Figure 9. **Discourse from whole-group discussions as coded from Don: Lesson 2.** For interpretation, see explanation in Figure 8.

From the standpoint of communicative approaches, there are few differences between how Don and Jim facilitated discourse in Lesson 2. As displayed in Figure 8, Jim succeeded in maintaining dialogic discourse for several prolonged sections throughout the lesson, similar to Don's lesson. Despite the frequent use of dialogic discourse in the role of moderator, student argumentation was observed to be completely absent in Jim's second lesson.

Comparison with the rich argumentation from Don's lesson (shown in Figure 9) indicates that the role of moderator alone may not be sufficient to facilitate argumentation. The role of moderator allows multiple student voices to be heard, but the expertise of the teacher may be needed to spur argumentation in the role of coach (see microanalysis in chapter 5.3.4), or the teacher may need to step back and allow students to speak freely in the role of participant (see microanalysis in chapter 5.3.2). The types of discourse used by Don in Lesson 2 ranges widely, representing a frequent use of the roles of coach and participant. This variety of discourse may have been the key difference between Don's teaching and Jim's teaching, affecting the level of student argumentation.

5.3 Microanalysis of discourse

RQ#4: What unique tactics do teachers use when playing various teacher questioning roles?

From open coding, several noteworthy instances were recorded, including Don deliberately lying to students to pretend that he do not know something, Jim habitually rephrasing sentences on the behalf of students, and Don reversing questions back to students instead of answering the questions himself. From each of the four lessons, one section of transcript was chosen to represent common themes and unique tactics that teachers use while playing various teacher questioning roles. These sections of transcript included below also serve to bring the four teacher roles to life, supplying real examples from the lessons. As noted previously, the translation process involved slight alterations of language in an effort to convey the content that was being discussed in each segment more clearly, and to make the talk sound more authentic and natural in the English language. To aid in understanding discussions included in the transcripts below, reference can be made to Appendix B, which includes the tasks that were given to students in each lesson.

5.3.1 Don: Lesson 1 – Moderator and participant

This first section of transcript (shown in Table 6) shows a good example of Don playing the role of moderator and, occasionally, participant. This exchange occurs in a whole-class discussion following a group activity in which students were presented with four statements describing a scenario involving three individuals seated in front of a mirror. Students were directed to choose one statement that they thought was correct, and supply written reasoning defending their choice.

Don begins this exchange in a very dialogic manner, which is exemplified by several dialogic indicators. Don begins by showing explicit interest in a student's idea. Dialogism is indicated by the teacher asking, on three separate occasions, for William to share his idea with the class (turns 1, 3, and 5). William's response is met with non-evaluative feedback from the teacher. The teacher's probing question in turn 5 is asked in a neutral way, and spurs further discussion from the other group members.

Dialogism is further supported in this case by the teacher's physical proximity to students. In this discussion, the chairs have been arranged so that the class is seated in a circle, and everyone is facing towards each other. The teacher is seated alongside students within this circle, thus signifying lessened authority. The teacher's body language also could be seen to play a role, as his neutral, relaxed position (seated, leaned back, feet crossed) is very unassuming and does not command any special respect or attention. The entire episode can be considered dialogic, as the conversation consistently revolves around students' ideas and reasoning.

Towards the beginning of this episode, Don acts as a moderator by bringing in a contrasting point of view from William. Don briefly shifts to coach as he asks William to defend his reasoning in turn 5. As Jacob explains their group's answer, Michael raises his hand to seek a speaking turn. Don then shifts to a participant's role and turns over full control of the conversation to the students by gesturing to Michael that the conversation can move forwards

unimpeded. This allows Michael to add his own clarification, which then opens the door to Matthew's counterclaim.

During turn 11, as Matthew offers his own counterclaim to William's group's statement, Matthew begins speaking directly at the teacher. However, Don's posture does not change at all, nor does he offer any gestures or other nonverbal cues to signify that he either agrees or disagrees with the student. One could almost assume that Don is ignoring the student. For a brief moment, Matthew pauses and maintains eye contact with Don, as if to seek acknowledgement or feedback from the teacher. However, as Don brilliantly maintains his "poker face", Matthew turns towards another part of the class and further explains his reasoning. In this moment, it seems appropriate to affix the label of participant to the teacher, as he abstains from offering input and behaves on a similar level to other members of the group. For much of this episode, students maintain ownership not only over the content, but also over the turn-taking norms of the discussion.

Don, seeing the need to clarify Matthew's point, asks another probing question in turn 13 and briefly returns to the role of coach before again shifting to participant. Don's neutral, non-evaluative feedback in turn 15 sets the stage for another student to later offer his own rebuttal of Matthew's point, leading to high-level student argumentation that continues beyond this segment of transcript and lasts over 15 turns without teacher input (see Appendix C, Table 11). Don's probing question in turn 13 further clarified Matthew's statement, helping other students to recognize flaws in his logic and emboldening them to engage in dialogue.

The teacher's use of multiple questioning roles supports an episode of student argumentation in turns 9-11, but as explained in chapter 5.2, this episode lacks a direct rebuttal and is considered only Level 2 argumentation. However, after Don continues probing for student reasoning at the end of this episode, another higher-level chain of argumentation begins, shown in Appendix C, Table 11.

Table 6. **Don: Lesson 1 segment** (Note: ellipses indicate omitted irrelevant text)

	Classroom discussion	Teacher Role
1	Don: William ...; what was your idea to start with?	Moderator
2	William: About what?	
3	Don: About this task. What was your idea, when you individually chose? So which choice was in your opinion the right answer?	Moderator
4	William: C	
5	Don: C. [Reads:] In the mirror, A and C see only each other. Why do you think that?	Coach
6	William: Well because, I dunno.	
7	Jacob: I can explain.	
8	William: Go ahead.	
9	Jacob: [talking to group] Well see, umm, William explained it to us, that if he looks, that if A looks in the mirror, then he doesn't, like, see person B, because he's like looking from the side. So, he sees, he would see only that person C, because like the light would be coming at like a 90 degree angle and he wouldn't be able to see person B, but you see, umm, it could definitely be possible, [Michael raises hand, waved on by teacher] that he would see the other person but, see, um, if you go with choice C, that persons A and C see only each other, then yeah it probably is true.	Participant
10	Michael: [talking to group/teacher (unclear)] Yeah and we tested it a little bit, that if I look from here then I don't see towards the center, nor do I see myself. So I see quite a bit of that edge, if the mirror would be right here [gesturing towards mirror at back of classroom]	
11	Matthew: [talking at teacher] But, you see, that option C could be true if every one of the people looks only at one specific spot on the mirror. [no response from teacher, shifts stance towards group] Because then the person can't see two people at the same time, when he looks precisely only at one spot.	Participant
12	Christopher: Right.	
13	Don: So, Matthew, are you saying that when you look in the mirror you can only see one person at a time?	Coach
14	Matthew: [to teacher] Well, clearly [as in, distinctly].	
15	Don: Okay..	Participant
16	Matthew: Or, you can only <i>look</i> at one person at a time.	

5.3.2 Jim: Lesson 1 – Passive participant

The following section of transcript (Table 7) offers a glimpse into how the same lesson is carried out by another teacher, Jim. This exchange would also be considered dialogic/interactive, as Jim explicitly seeks out students' ideas and responds in a non-evaluative manner. In turns 21 and 24, Jim acts as a moderator, simply drawing out student ideas and orchestrating the conversation. After turn 24, Jim remains seated at the front of the class and does not attempt to control the discussion until turn 46, allowing the students to speak freely. This gives rise to a rich student-led discussion. In turns 25-45, several students engage in what could be considered Level 4 argumentation, as a clear rebuttal is present (turn 25: "No, they wouldn't see"). This rebuttal contains a clear indicator of student opposition, as the entire statement is structured in a way that communicates disagreement ("No, they wouldn't..."). This is then followed by data (turn 29: light bounces at that kind of an angle) and warrants (for example, turn 37: "I wouldn't see myself if the mirror is over there"). A counterclaim is present ("he would see a maximum of half of himself", turns 28, 32, 34, 45), but the argumentation does not develop beyond this point. While the students are arguing (in the very common sense of the word), Jim remains a passive participant in the conversation and allows it to progress unimpeded. For this reason, the label of participant is again appropriate, as students maintain control of the conversation for several turns. After this series of statements, Jim simply moves on (turn 46), without attempting to sort out what took place. Although the students had just engaged in relatively high-level argumentation, Jim does not seek to build from it, nor does he even acknowledge it beyond a simple statement of "Okay, good" (turn 46). By intervening again in the role of coach or moderator, the argumentation could have possibly continued to a deeper level and its components could have been made more explicit to all student.

From the perspective of conceptual link-making, it seems that Jim had limited success in this episode. He is able to set the stage for students to engage in argumentation, but fails to take full advantage of the rich variety of ideas

presented by the students. It is unclear whether all members of the group were able to follow along with the chain of logic presented by the other students, since this entire conversation occurs quite rapidly, with multiple overlapping turns of conversation. The group in question (Madison's group) seems to play an active role in defending their answer, and Madison herself seems to have reached a new conclusion by the end of the debate (turn 41). While it could be argued that Madison has been able to create new conceptual links between her prior knowledge and the new ideas presented by her classmates, Jim fails to identify this development explicitly, and perhaps misses the opportunity to facilitate the link-making process for other students. As Jim moves on to the next group (turn 46), he does not allude in any way to the previous conversation, and fails to frame the subsequent conversation in terms of what just happened.

Table 7. **Jim: Lesson 1 segment** (Note: ellipses indicate omitted irrelevant text)

	Classroom discussion	Teacher Role
21	Jim: So how about groups 3 and 4, ... when you heard what Madison said and what Jessica said, then is there	Moderator
22	Nicholas: Yeah.	
23	Emily: Well Madison could have, perhaps, or your group could have perhaps opened it up a little bit more, about your answer, because I didn't understand it very well.	
24	Jim: [butts in quickly] So, in their opinion the correct claim was, that everyone is able to see everyone else in the situation shown in the picture.	Moderator
25	Students: [overlapping] no they wouldn't see.. Person C doesn't see himself.. He's looking from that angle like,	
26	Madison: But is he looking straight or is he looking at the mirror?	
27	Andrew: Well he doesn't see into the mirror, if he looks	
28	Hannah: He sees a maximum of half of himself	
29	Joseph: The light bounces at that kind of an angle, that it's not physically possible.	
30	Anthony: ...	
31	Daniel: Nothing is impossible Joseph	

32	Madison:	Or in my opinion he sees a maximum of half of himself	
33	Andrew:	Don't yell.	Participant
34	Madison:	I feel that he would see half of himself	
35	Hannah:	But, wouldn't I,	
36		[unintelligible]	
37	Joseph:	I wouldn't see myself, if the mirror is over there	
38	Emily:	But through the mirror you'd see the others	
39	Joseph:	But he wouldn't see himself	
40	Emily:	He doesn't see himself at all, but everyone else, yes.	
41	Madison:	Oh, right.	
42	Emily:	He sees everyone else, but not himself.	
43	Joseph:	If I'm person C, then I wouldn't see myself.	
44	Andrew:	You see only half of yourself.	
45	Anthony:	A maximum of half	
46	Jim:	Okay, good. Now, group two. Now Anthony you can read your group's answer.	Moderator

5.3.3 Jim: Lesson 2 - Dispenser

For the next example of discourse in Table 8, we remain with Jim, but move on to a different lesson. Prior to this episode, the students have completed a group activity in which they used lettered fact cards with true statements to either support or refute a claim regarding the accuracy of a temperature vs. time graph. Here, they use a fact card, identified in the transcript as “statement G”, to defend the claim that the given graph does not depict ice being heated into water and eventually boiled into steam. The lesson materials are also included in further detail in Appendix B.

This episode begins in a dialogic manner as Jim opens the floor to David (turn 51), but Jim quickly takes an authoritative stance by re-phrasing David’s statements and adding his own interpretation to David’s idea. Turn 53 represents a shift back to authoritative discourse and the role of dispenser, as Jim begins using a presentation-style “teacher voice” and stands in front of the class as he guides the discussion. Jim’s role in turn 53 is similar to that of moderator, but because he begins adding his own interpretations and observations (“this graph however is a totally straight line”), he is acting more in the role of dispensing information. Had Jim simply rephrased what the

student said, the role of moderator would apply, but Jim goes far beyond what David says in interpreting the relationship between his reasoning and the displayed graph.

Jim retains tight control over the content and flow of discussion in turns 54, 56, 58, and 60, and utilizes a triadic Initiate-Response-Evaluate pattern (turns 58-60 and 60-62). Turn 58 especially provides an excellent example of closed questioning, and even the way in which Jim phrases his question implies that he is looking for only one correct answer. The student's contributions are used merely to fill a gap in the teacher's pre-planned discourse, and the teacher indicates that the exchange was carried out successfully with evaluative feedback (turn 60). This indicates authoritative discourse, and provides an example of how a teacher may play the role of dispenser in an interactive fashion.

Throughout this episode, students are merely following the lead of the teacher, supplying fill-in-the-blank types of answers, and are given few opportunities to defend their own reasoning fully, as the teacher relies heavily on the role of dispenser to lead classroom discourse. It comes as no surprise, then, that student opposition and robust argumentation are not present in this section of discourse.

Table 8. **Jim: Lesson 2 transcript segment** (Note: ellipses indicate omitted irrelevant text)

	Classroom discussion	Teacher Role
51 Jim:	Alright, sorry. Does everyone have statement G available, and here's the graph, and then David, continue.	Moderator
52 David:	Uumm, we need three different phases of matter, and water boils at 100 degrees. Before we get to that point it requires 2 phase - , umm, changes, but if the temperature doesn't change, then changes won't occur.	
53 Jim:	[Showing graph on screen:] So in other words in this space between here, there should be 2 phase changes. But this graph however is a totally straight line.	Dispenser
54 Jim:	Yeah. And then how did your last part go?	Dispenser

55	David:	So, yeah, umm, if the temperature doesn't change, then changes don't occur.	
56	Jim:	If the temperature doesn't change, then changes don't occur... Right right, you mean you have to heat it up, so that you can get phase changes. Yup yup yup. But what does it say on the G-card? Read that card again. Or whoever wants can read it.	Dispenser
57	David:	[Reads:] During the time of phase changes, the temperature of a substance doesn't change.	
58	Jim:	During the time of phase changes, the temperature of a substance doesn't change. [Points at graph] Are there places on this graph, where the temperature of the substance isn't changing?	Dispenser
59	Ashley:	No.	
60	Jim:	No, there isn't. At least it doesn't look like it. But however there should be how many of them? Madison.	Dispenser
61	Madison:	Two.	
62	Jim:	Right. [Points back at David's group] And then, did you have anything else?	Moderator
63	Joseph:	No.	
64	Jim:	Does everyone else agree, that this graph is incorrect?	Moderator
65	Anthony:	Yes.	
66	Jim:	[chuckles] Unanimously.	[Off-topic]

5.3.4 Don: Lesson 2 - Moderator and coach

For the last example of classroom discourse in Table 9, we return to Don's class working on the same lesson portrayed in Jim: Lesson 2. Immediately prior to this exchange, statement G was offered in support of a group's claim that the graph incorrectly showed a heating curve of water. Don begins in turn 71 with a probing question of the validity of G as a supporting statement. Noticeably, 10 seconds elapse before a student responds, indicating Don's patience and interest in students' ideas. In turns 75 and 77, Don takes the role of coach and embarks on a series of questions, which challenge Matthew's idea. By challenging the student's idea, Don has opened the door for other students to comment on this line of thinking and to engage in argumentation. This opportunity may not have presented itself to the students without the teacher's

expertise in guiding the discussion by presenting challenging questions. After this exchange, Don then invites other students into the dialogue in the role of moderator (turn 79). When an opposing view is brought out, Don orchestrates the discussion by contrasting Matthew's and Joshua's ideas and helping to integrate these two ideas together into a single narrative. Don explicitly points out the fact that there are opposing ideas present (turn 88), and very effectively sets the stage for Matthew and Joshua to engage in argumentation.

The sequence that follows was classified as Level 5 argumentation, due to the presence of multiple rebuttals. For instance, in turn 72, Matthew rebuts the claim that Statement G supports the boys claim. Following this, in turn 93, Joshua rebuts Matthew's assertion, leading his statement with "but in my opinion," which indicates opposition with the other student's point of view. Matthew and Joshua offer supporting data and warrants, indicating a high level of argumentation. Joshua's rebuttal directly addresses Matthew's interpretation of the graph. More specifically, Matthew thinks that the first phase change occurs in the correct location on the graph, but Joshua points out that the first phase change actually occurs at four degrees Celsius, and not zero (see temperature graph B in Appendix B). Both Matthew and Joshua refer explicitly to the data (on the graph displayed on the classroom projector), pointing out specific locations where they believe that Statement G is or is not in direct contradiction with the graph. By specifically addressing the components of Matthew's argument, Joshua is able to move beyond simply contrasting two viewpoints, and succeeds in changing Matthew's mind (turn 94). This student-led argumentation is maintained by Don acting as a moderator in turn 92, immediately deflecting Matthew's comments towards Joshua.

In this episode, dialogic discourse is maintained and masterfully facilitated by Don. During a few critical moments, Don plays the role of coach and challenges students' ideas, and then steps back to allow students to take up the discussion. It seems quite clear that the students are communicating directly to each other, rather than the teacher constantly filtering what students say. Don's body language also seems to indicate on more than one occasion

that he does not intend to dominate the discussion, and he offers the floor to students by standing off to the side of the class. Don returns to the front/center of the class only in order to point at various sections of the graph while students narrate. Another dialogic indicator was present prior to this discussion, when Don had further reduced his authority on the subject by claiming to the whole class that he knew nothing about the topic, a gesture in which he attempted to shift the responsibility of thinking and reasoning onto the students

Table 9. Don: Lesson 2 transcript segment

	Classroom discussion	Teacher Role
71	Don: Could that statement G still hold up? Does it support, that the claim is incorrect? [10 seconds wait time] [Reads:] A substance, um. During the time of a phase change, the temperature of a substance does not change.	Coach
72	Matthew: In my opinion it doesn't support it.	Moderator
73	Don: The boys' claim.	
74	Matthew: Right.	
75	Don: Why not?	Coach
76	Matthew: Because, in that spot where it changes from ice to water then it supports that the graph is correct, but the question of, what happens during the time when you heat it to 100 degrees, then it doesn't show whether or not it continues with a horizontal line.	Coach
77	Don: Well it's right there: 100 degrees.	
78	Matthew: Right, but the line ends at that point	
79	Don: But could it - so, the boys claim that this is wrong, this graph. ... That graph doesn't show the situation where water is heated from ice to steam. Does this statement G support the boys' claim?	Moderator
80	Matthew: No.	Coach
81	Don: No. Because?	
82	Joshua: But in my opinion	
83	Matthew: Well,	Moderator
84	Don: Hey.	
85	Joshua: G supports that.	
86	Don: Supports what?	Moderator
87	Joshua: That it [teacher gestures at graph] is wrong.	Moderator
88	Don: Okay. Now we have two different opinions. Matthew, you can start. Joshua will follow and listen carefully, and the rest of you listen as well. Alright.	

- 89 Matthew: Well, hmm. [Reads from statement card:] During the time of phase changes the temperature of a substance doesn't change. So, in all of the places where there would be a phase change, then, there is a straight line. Or there isn't. Or it doesn't show it at all.
- 90 William: Huh?
- 91 Matthew: Like, ... I don't see anywhere there that kind of a point, where the phase should change, but where the temperature increase continues nevertheless all the same.
- 92 Don: Well how would Joshua answer this? Moderator
- 93 Joshua: Well, right. In my opinion, that G supports it because, well firstly that spot where the lower horizontal line goes, like it's something close to 4 degrees probably. And then that upper horizontal line is close to 79, um, Celsius. And, I think that it supports it because of the fact, that the substance which we are heating, its phase changes do not occur in those same spots.
- 94 Matthew: OK, ahaa.
-

6 DISCUSSION

6.1 Quality

In assessing the overall quality of this study, a challenge presents itself in finding an appropriate set of criteria for assessment. Due to the wide variety of qualitative methodologies and contexts, Flick (2007) contests whether or not a universal set of criteria can be used to assess the quality of unique studies found in differing contexts. One approach to assessing quality involves modifying three classical criteria from empirical social research: reliability, validity, and objectivity. Although these criteria originate from quantitative research, they will be used to frame the discussion of quality for this study.

6.1.1 Reliability

In terms of the reliability of this study, efforts were made to make the interpretation and analysis of data as transparent as possible. By including the coding manual in the appendices, the process of analysis is made more visible to the reader, and the sections of microanalysis offer an intimate look into how judgments were made regarding types of discourse and levels of student argumentation. By including a second coder in two rounds of analysis of communicative approach and teacher questioning roles, the inter-rater reliability of the study increased, yielding a higher Cohen's κ value. Having a second researcher involved in the analysis not only helped to confirm the usefulness of the rating scales, but it also helped to further clarify implicit decisions that were being made in the process of data analysis. By communicating the decision-making processes with a second researcher, the essential features of each model were brought to the surface and made explicit either in the methodology section of this manuscript or in the coding manual.

While application of all of the theoretical frameworks used in this study required judgment calls on the part of the researcher, the process of rating student argumentation levels proved to be especially complex. As echoed by Nielsen (2013), the use of TAP as a basis for analysis can be quite problematic, especially when distinguishing between data and warrants. Furthermore, TAP is based not so much upon discursive elements of talk, but more closely resembles dialectical analysis, as it investigates the logical structures of argumentation. This requires a great deal of interpretation, resolution of disagreements between coders, and "numerous decisions ... to match specific pieces of data to the Toulminian codes" (Lunsford, 2002, in Nielsen, 2013, p. 384). The process of interpretation, negotiation, and revision for this study are described in quite some detail, but a great deal of the analysis of argumentation remains hidden beneath the surface. Thus, the use of TAP in assessing argumentation raises some questions of reliability. To address this issue, feedback from other researchers familiar with TAP were consulted to clarify its use.

6.1.2 Validity

This research study endeavored to conduct a multi-level analysis of discourse in lower secondary science classes. The instruments of analysis chosen for use ranged from more-established tools including Mortimer and Scott's communicative approaches framework and an operationalization of TAP developed by Erduran, Simon, and Osborne, to a recently developed tool in the teacher questioning roles framework. Modeling after discussions of validity found within Scott et al. (2006), four criteria will be used to assess the validity of discourse analysis found within this study: convergence, agreement, coverage, and linguistic details (Gee, 2005).

Gee (2005) offers an extensive list of 26 considerations upon which analysis should be framed discourse analysis. An ideal discourse analysis is designed in a way that approaches discourse from multiple perspectives and supplies answers to a variety of questions, accounting for the relationships between speakers, activities that take place within the situation of interest, relevant systems of knowledge, situated meanings, and various roles and identities of speakers. Gee's first validity criterion of convergence refers to the ability for the analysis to supply "*compatible and convincing answers*" (Gee, 2005, p.113, emphasis in original) to as many of these considerations as possible. The more opportunities there are for the above considerations to converge in a discourse analysis, the more valid that analysis is considered to be. Thus, discourse analysis is not intended to focus only on isolated elements of speaking, but rather on the entire communication act.

The concept of convergence is integrated into the present study, as the analysis was designed to allow several factors of discourse to converge together. These included questions of how connections were made across sections of discourse, what types of relationships were present and relevant, how identities were constructed within the discourse, and what situated meaning was attached to various acts of speech. These questions are integrated into the frameworks used in the study, and analysis was able to provide compatible answers to many of these considerations.

Gee's concept of agreement refers to whether or not "native speakers" of the social language in which discourse occurs would agree that the analysis "reflects how such social languages actually can function in such settings" (Gee, 2005, p. 113). This broad concept of agreement is present in the methodology presented in chapter 4, as researcher triangulation was an important step of the analysis. All researchers involved in the present study have personal experience as physics teachers, thus providing an authentic lens through which classroom interactions and discourse were interpreted. In a more literal sense of the term, native speakers of Finnish were also involved in the process of analysis of the lessons, which were taught in Finnish.

The third criterion, coverage, suggests that analysis is valid if it can be applied to other sets of related data. The analysis applied to this study fulfills this category, as it has been used to describe discourse in multiple studies in various contexts. Nielsen (2013) identifies over a dozen studies that use the five-level argumentation model from Erduran et al. (2004), and Mortimer and Scott's communicative approaches model has appeared multiple times in other studies (Chen et al., 2017; Lehesvuori et al., 2017a; Lehesvuori et al., 2013; Nurkka et al., 2014; & Scott et al., 2011). The framework describing teacher questioning roles used in this study has been developed from the communicative approaches model, and based on its transferability to the new context in this study, seems to apply to a broad spectrum of classroom discourse.

Lastly, the criterion of linguistic detail can be applied to analyze the validity of this study. Linguistic detail refers to analysis that is directly tied to grammatical devices that exist within discourse. Gee (2005) states that "analysis is more valid the more it is tightly tied to details of linguistic structure" (p. 114). Linguistic structures such as dialogic indicators were directly used to analyze the level of dialogicity, and key words or phrases such as "but in my opinion" and "no" were sought out to identify instances of student opposition to signify episodes of student argumentation. However, as mentioned previously, analysis of argumentation was often more closely tied to the logical structures

of argumentation rather than to specific linguistic cues. At times the analysis of teacher questioning roles involved scrutinizing the teacher's use of personal pronouns to investigate how phrases such as "what do you think," "your idea," and "his/her idea" were used. The specific question words used by the teacher, such as "why", "what", or "how" also gave indication to the type of teacher questioning role present in discourse further tying analysis to linguistic details. Thus, although the discourse analysis used in this study utilized a variety of methodological tools, it can be assessed as having a moderate level of validity according to the criteria of convergence, agreement, coverage, and linguistic details.

6.1.3 Objectivity

As the nature of this study required intensive interpretation and framing of data on the part of the researcher, objectivity per se was not a main focus of the research. However, by using analytical tools that have been externally developed, the author sought to let the data speak for itself as much as possible. The researcher's own ideas and interpretations were nonetheless present throughout the process of analysis, affecting a myriad of decisions including which research questions to ask, how to represent speech in the transcript, which interpretive frameworks to use, and the how to extract data from discourse. Discourse in the science classroom uses its own unique social language, however, and in intimate familiarity with these cultural norms is seen as an asset, rather than a hindrance, to this type of research.

Objectivity in qualitative research could be viewed as an oxymoron, as subjectivity is at the crux of the process in which a researcher interprets and extracts meaning from complex data. However, Ratner (2002) argues that if subjectivity is appropriately organized and managed, it allows for an objective interpretation of the social psychological world. By recognizing the incoming subjectivity and biases one has, a researcher can then "reflect on whether or not (one's subjectivity) facilitates or impedes objective comprehension" (Ratner, 2002, par. 7). Essentially, awareness of the perspective that one uses to

approach a subject allows for a richer interpretation and deeper insights. It is in this spirit that the author approaches educational discourse, drawing on previous experiences and “teaching instincts” throughout the process of analysis. The author’s subjectivity, however, was constrained by the use of systematic interpretations based on theoretical frameworks as described in chapter 4.

Objectivity can also be interpreted as “consistency of meaning” (Flick, 2007, p. 15), indicated when independent researchers arrive at similar conclusions upon examining the same data. This principle was prevalent throughout the process of analysis in this study, exemplified for instance in the use of multiple coders when analyzing teacher questioning roles. Thus, although subjectivity was present at many levels in this study, it was used to construct an objective representation of phenomena within the data.

6.2 Findings

The first research question aimed to investigate the types of roles that teachers play when aiming to facilitate student dialogue and argumentation. As discussed in chapter 5, a variety of roles was observed throughout all of the lessons. The first teacher, Jim, utilized the roles of dispenser and moderator the most, aligning with findings by Chen et al. (2017), which described teacher’s use of questioning roles at the beginning of a professional development program. The variety of teacher questioning roles used by Don, however, aligned more closely with profiles of teachers who had already received three or four years of specific training targeting the teacher’s role in facilitating argumentative discourse. This seems to signify that Don was already rather advanced in his questioning skills, possibly as a result of previous training or professional development.

A basic pattern was also observed from both teachers regarding their use of teacher questioning roles. On several occasions, the teachers tended to follow a progression from dispenser to moderator, and then on to either coach

or participant. It seems quite logical that students' ideas should be first collected before the teacher can critique them or allow the class to engage freely in discourse about the idea. Although this progression seems rather intuitive, it is interesting to note that the data analysis also supports this. This raises a further question to be considered: at which stages of a discussion are the various teacher roles most appropriate?

The second research question addressed the relationship between communicative approaches and teacher questioning roles. As summarized in chapter 5, more than one communicative approach was observed in conjunction with three of the teacher questioning roles. The lone exception, participant, was observed being carried out with only a dialogic/interactive approach. This implies that it is possible to facilitate more than one type of discourse while using the same communicative approach. For example, authoritative/interactive discourse could fit the description of either dispenser or coach, depending on how a teacher uses their questions. If the purpose were simply to deliver factual information and evaluate student understanding, it would fit the description of dispenser. However, if a closed question were used as a part of a questioning routine that is intended to challenge or clarify a student's ideas, then it would fit the description of coach. It seems that the historical aspect of talk is very important in making this distinction, as the purpose that a question fulfills depends significantly on what kind of talk precedes it.

In comparing the two frameworks (communicative approaches and teacher questioning roles), it seems that each framework places more of an emphasis in differentiating between talk on separate ends of the spectrum. The communicative approaches model distinguishes between authoritative talk that is interactive or non-interactive, while the findings of this study suggest that the teacher questioning roles framework lumps most authoritative talk into one category, labeled as dispenser. However, concerning dialogic talk, the teacher questioning roles framework was observed to distribute dialogic/interactive talk among three different categories: coach, moderator, and participant. Seeing

as three of the four teacher questioning roles rely heavily on dialogic talk, this further emphasizes the importance of integrating dialogicity into classroom discourse.

Research Question #3 aimed to identify which communicative strategies are effective at facilitating student argumentation. The findings of this study suggest, among other things, that it is indeed possible for lower secondary students to engage in high-level argumentation if the opportunity is presented. Several instances of level 3, 4, and 5 argumentation were observed, exemplifying these students' ability to construct and defend complex arguments about science, painting a much more hopeful image of student argumentation than described by Watson et al. (2004). This study also revealed that dialogicity alone may not be sufficient to facilitate argumentation in the science classroom. Several portions of discourse included a high frequency of the role of moderator, but argumentation was best supported when a greater variety of teacher questioning roles was present. The role of moderator has limited purposes, and the ability of a teacher to react to discourse in a flexible manner was shown to be beneficial in supporting argumentation.

The breadth of this study was limited, however, and failed to describe with much certainty the relationship between teacher questioning roles and student argumentation. A study of larger scale and narrower scope would be appropriate to investigate this relationship further, as this study served merely to open inquiry into the topic.

The fourth and final research question explored the unique tactics that teachers use when playing various teacher questioning roles. In playing the role of dispenser, teachers tended to minimize uncertainty and offered clear answers to questions posed either by students or by the teacher. In the role of dispenser, teachers also used discourse as a way of exerting authority and power over the students, and made it clear to students if they were conforming to expectations.

In contrast, in the role of participant, teachers deflected the authoritative role and forced students to embrace uncertainty. Teachers accomplished this by

avoiding eye contact, not responding to students, or even playing dumb. By using these tactics, teachers made it clear that student discourse was meant to be focused towards their peers, and not at the teacher. The role of moderator similarly left the teacher in a neutral role of merely rephrasing ideas to move the conversation along.

The role of coach was especially interesting to analyze, as both authoritative and dialogic discourse were used to play this role in various instances. As a coach, the teacher played a bold role, asking probing questions, pitting one answer against another, and at times forcing students to think on the spot and defend their answer in front of the whole class, which is indeed no small feat for a student in lower secondary school. Teachers used their own subject expertise in the role of coach to guide the discussion, foreseeing possible student misconceptions and refining ideas to their basic elements. Due to questions that probed at students' deeper understandings, students were offered an avenue into argumentation, granted that the teacher opened up enough space for students to exchange ideas freely.

6.3 Reflections

This study was clearly limited by its scope, as it only described teacher behaviors and classroom interactions within a specific context. Thus, many more steps remain to be taken before any assessment of best practices can be made. Although this study described the effectiveness of teacher roles in supporting argumentation, one should use caution in generalizing to other contexts. Important considerations include the educational culture in which the discourse takes place, teachers' experience in facilitating dialogue, and the learning objectives and curriculum driving the instruction. The teacher roles in this study all take place within a backdrop of other factors, including the Finnish educational culture, national curriculum documents, and power dynamics in schools. Furthermore, at the heart of teacher actions is a teacher's identity and agency, and in order for these teacher roles to be enacted in an

authentic fashion, an alignment of goals, motivations, and professional identity must take place, gradually resulting in a shift in a teacher's theory of practice.

Nonetheless, the challenges encountered by the teachers in this study are by no means unique to science education in Finland. Similarly, the goal of facilitating dialogic argumentative discourse is one shared by passionate science teachers across the globe. This study aimed to identify in a more concrete way how the task of facilitating discourse can be accomplished and can thus be used to inform teacher professional development and teacher training.

This study succeeded in drawing a comparison between two related frameworks, and can serve to clarify the utilization of each. While this study offers a preliminary finding that the teacher questioning roles framework is a reliable research instrument, much less ambiguity seems to exist within the communicative approaches framework. The categorization of communicative approaches offers a reliable research instrument, but the teacher questioning roles may offer more promise in the realm of teacher training and professional development.

The observations in this study regarding the use of teacher roles are not to imply that one role should be emphasized more than others should, but rather that the use of multiple roles allows a teacher to fulfill various pedagogical purposes and facilitate a range of discourse in the science classroom. The use of the teacher questioning roles model could serve as a powerful tool in professional development and teacher training, as it offers a coherent, intelligible framework to teachers. A metaphor to acting seems appropriate in this instance, as actors could focus either on merely memorizing lines, or they could alternatively learn the essence of their character. By studying ones' character, an actor learns how this character would respond in different situations and can rely on a more holistic understanding of the plot, rather than being relegated to rote memorization of their part. In a comparable fashion, the task of orchestrating whole-class discussions is very demanding of teachers, and preparing for facilitating dialogue could take several different forms.

Writing prepared questions or a script ahead of time can be an exercise in futility, as it is close to impossible to predict exactly where a conversation involving a group of students will go. Content-related discussions vary widely based on a multitude of factors including students' prior knowledge, their own data and experiences, their willingness to contribute to conversations, and social norms, to list a few. One set of questions could work excellently for one group of students but be met with silence by another group of students. Thus, the focus need not be on exactly what teachers say, but rather on what type of roles they play in facilitating conversation. A close familiarity with the various teacher questioning roles would allow a teacher to improvise and respond to situations based on the role that they wish to play, rather than cling to a predefined course of discussion. In this study, questioning roles were extracted from discourse, but the framework could also be a powerful tool to promote teachers' self-reflection of the appropriateness and effectiveness of their use of various roles.

To improve the methodology of this study, a larger data set could be used with more rounds of revision in the coding process. This would increase the reliability of findings and make it more appropriate for generalizations to be made to different contexts. It would perhaps be best to focus on fewer dimensions of discourse to create more refined conclusions, although there are merits to using a multi-level approach to discourse analysis.

Further research could be conducted into teacher roles when intervening in student group work, as this topic was shortly explored during the initial round of open coding. Noteworthy differences were observed, as individual teachers maintained very different roles in their interactions with small groups of students. The role of participant and coach were noted several times during Don's interactions with small groups, while Jim's interactions with students in small groups closely resembled his interactions with the entire class. It seems that the teacher questioning roles can be expanded far beyond discussions in a whole-class setting, and perhaps could be appropriate in describing individual interactions.

Teaching can be described as an art, implying that those who possess a good eye for teaching excel at their craft, relying on their own intuition and instincts. However, teaching has also been argued to be a science, with its body of knowledge centered on learning theory and developmental psychology. In 1979, Hestenes writes that “an ample foundation for a science of teaching exists already today” (Hestenes, 1979, p. 235). Hestenes also advocates for a more student-centered approach to teaching based on developmental psychology. Close to 40 years later, the discussion of how to define best practices in science education still sounds strikingly familiar.

This study aimed to describe how science instruction can make room for students’ voices and engage them in the process of argumentation. In this way, teaching can be a process of negotiation between the teacher and students, rather than “an affair between (the teacher) and the blackboard” (Hestenes, 1979, p. 241). By recognizing and drawing attention to the impact that teacher questioning roles have on student dialogue and argumentation, it is hoped that future science educators can adopt practices of discourse that further enable students to become active participants in the construction of scientific knowledge.

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APPENDICES

A. CODING MANUAL

Communicative approaches (Mortimer & Scott, 2003).

Discourse was analyzed based on the type of communicative approach present. Each episode of conversation was assigned a code which portrayed what type of communicative approach was dominant in that episode. Determining what consisted as an episode of conversation was slightly arbitrary, but for the most part any time the topic of conversation moved on to a new topic (often signified by a teacher asking a new question), it was considered a new episode of conversation. Also, any time there was a clear shift in communicative approach (the teacher trying a new strategy), a new code was assigned.

Codes were assigned as follows:

- 0 = O: Off-topic
- 1 = A/N: Authoritative, non-interactive
- 2 = A/I: Authoritative, interactive
- 3 = D/N: Dialogic, non-interactive
- 4 = D/I: Dialogic, interactive

Authoritative, non-interactive:

Communication is controlled explicitly by the teacher, with no prompts for student input. The content is centered around the authoritative, teacher-centered point of view.

Authoritative, interactive:

Students, as well as the teacher contribute to the conversation. The content is centered around the authoritative, teacher-centered point of view, and the teacher provides evaluative feedback to student contributions.

Dialogic, non-interactive:

The teacher does not seek student input and delivers a one-way act of speaking, but the content of discussion is centered around multiple viewpoints. The teacher acts as an unfinalized speaker and remains nonevaluative.

Dialogic, interactive:

Students and teachers contribute to the conversation. Student voices are valued and the content of discussion is centered around multiple viewpoints. The teacher acts as an unfinalized speaker and remains nonevaluative.

Teacher roles (Chen et al., 2017)

Each utterance from the teacher was assigned one of the following codes:

- 0 = I: irrelevant
- 1 = D: dispenser
- 2 = M: moderator
- 3 = C: coach
- 4 = P: participant

Irrelevant:

This code applied whenever the communication act of the teacher did not fit any of the other categories. Examples: the teacher is chatting with students (social talk), correcting behavior/ disciplining students, irrelevant side comments, or the utterance is an incomplete phrase which is not recognized/received by students (for example, if the teacher begins talking but does not continue the phrase). If an utterance is not related to content-related academic discourse, this code can be used.

Example 1: (incomplete)

Student: ...but we were thinking of choice B instead..

Teacher: But..

Student: ..because after talking about it we ..

Example 2: (off-topic)

Student: ..and our graph showed a gradual increase the whole time.

Teacher: (displaying graph) I'm not sure if you can see this at the back of the room.

Dispenser:

This code was used when the teacher maintains ownership of the ideas and ownership of the activity. This occurs when communication is authoritative, teacher-centered, and the teacher controls the flow of conversation. Non-interactive lecture-style presentation fits this category, as well as interactive triadic IRE patterns in which the teacher uses student input as "filler material" on their way to establishing a point. Questions in the dispenser role are often closed questions, with a clear right or wrong answer. The teacher delivers information to the students in this role. The teacher is not only leading the discussion, but also dictates when and how students respond. Verbal cues of dispenser can sometimes include when the teacher uses an

authoritative presentational “teacher voice” and creates distance between themselves and the students.

Example 1: (Evaluative)

Teacher: It gave off energy in the form of heat, making this what type of reaction?

Student: Endothermic.

Teacher: No, it would be exothermic in this case.

Example 2: (Evaluative, and the teacher uses student response to make their own point)

Teacher: Did the velocity of the car change at all during this time interval?

Student: No.

Teacher: Right, so therefore the acceleration at this point is zero.

Moderator:

In this role, the conversation is centered on students’ ideas, but the teacher is playing an active role in facilitating the conversation. The teacher solicits input from students, sequences ideas, asks open questions, draws out ideas, and asks students to build off of or respond to each others’ ideas. The teacher isn’t trying to push his/her own ideas into the conversation, but instead creates a “verbal jigsaw” that includes many different students’ perspectives. The teacher can comment on ideas to draw out more thinking, but is non-evaluative and non-judgmental of student ideas.

Short, “closed” questions with a short response can sometimes fit into this category, if the question is centered on students’ ideas and used to bring out their viewpoints. This requires a judgment call to decide if the teacher is showing interest in students’ ideas.

Example 1: (recognizing ideas)

Teacher: Melissa was saying that she thinks that air doesn’t have weight. Does anyone have anything to add?

Example 2: (integrating ideas)

Teacher: I heard from the first group that they think salt is a molecular compound, but then this group was referring to ions. What do you think of that, Robby?

Example 3: (recognizing ideas)

Teacher: Could a group share with the class what they selected for the first option?

Coach:

In this role, the teacher is giving students space to think and reason through something, but is adding their own input by challenging ideas and asking students to defend their reasoning. The teacher isn't delivering information to the students, but uses this questioning role to help students build a more complex and interconnected understanding of a topic. Simply asking for a student to elaborate on an answer isn't necessarily the role of coach, but when the teacher asks probing questions that drive at the "reasoning behind the reason", then it could be considered the role of coach. In the role of coach, the teacher takes more ownership of the ideas and attempts to direct student thinking. In this sense, it is similar to dispenser, but the teacher still gives students space to reason themselves. Closed questions with an evaluative response indicate the role of dispenser, but challenging questions that elicit thinking fit into the role of coach.

Example 1: (eliciting ideas)

Student: Car #1, because it has more mass.

Teacher: OK, but what does mass have to do with it?

Student: Well because if it has more mass then there is more downward force on the ramp.

Teacher: What do you think, Megan? What kind of effect does the downward force have on the amount of friction?

Example 2: (challenging)

Teacher: Charles pointed out that most of the metals were less reactive than the non-metals. But did anyone find any exceptions to that rule?

Student: Well the Lithium and Sodium were much more reactive.

Teacher: Ok, now do those elements have anything in common?

Participant:

In this role, the teacher relinquishes control of the discussion to the students. The teacher allows for students to maintain ownership over the ideas, as well as ownership over the activity (i.e. turn-taking, communication norms). The teacher can be a participant in the conversation, but is not taking a leadership role. The teacher can encourage participation and invite students to self-evaluate.

Although this was not clearly indicated in other research, this definition has been expanded to include moments where the teacher has intentionally "stepped back" and given the floor completely to students. This may include periods of teacher silence, in which case there is no "utterance" to code, so in these long stretches of student-led dialogue, if the teacher is not saying anything, then these instances of teacher silence could be considered instances of "Participant."

Example 1: (Encouraging participation)

Student: And so then we noticed, that as we kept adding more water to the solution, the color was changing.

Teacher: That's very interesting!

Student: Yeah and then eventually the green was gone altogether.

Example 2: (Teacher giving space to students)

Student 1: After another 50 meters, the car would probably turn around.

Student 2: But there's no way to tell that based on the graph.

Student 1: But you would be able to calculate it, because you know the mass of the car and how much force is being applied.

Teacher: - - (silence)

Student 2: Ok, but we still don't know how fast the car was moving to begin with.

Student argumentation level (from Erduran et al., 2004)

Student discourse was reviewed and any instances of direct student opposition were analyzed for their argumentation level. Discourse in which there was no direct student opposition was not coded. Episodes in which there was direct student opposition were then analyzed and assigned one of the following 5 codes shown in Table 10:

Table 10: Analytical tool for assessing argumentation level

Level 1	Level 1 argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim.
Level 2	Level 2 argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals.
Level 3	Level 3 argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal.
Level 4	Level 4 argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.
Level 5	Level 5 argumentation displays an extended argument with more than one rebuttal.

Note: only 1 code was assigned for each episode of argument. Again, it was at times problematic to determine when an episode of argumentation began and ended, but by focusing on the content of the core of the argument, it was possible in most cases to identify a beginning and end of student opposition.

B. ARGUMENTATION TASKS USED IN LESSONS

For reference, the argumentation tasks used in each lesson are included here. These tasks were given to students to work on in groups as a precursor to a whole-class discussion.

Lesson 1: At a mirror Names: _____

Persons A, B, and C are seated at a table, looking at a mirror that is about 0.5 meters away, as shown in the diagram. From the following list, select one statement that you think is true.

- a) A sees only himself in the mirror.
- b) Only B can see everyone in the mirror.
- c) A and C can only see each other in the mirror.
- d) B is the only person who can see himself in the mirror.

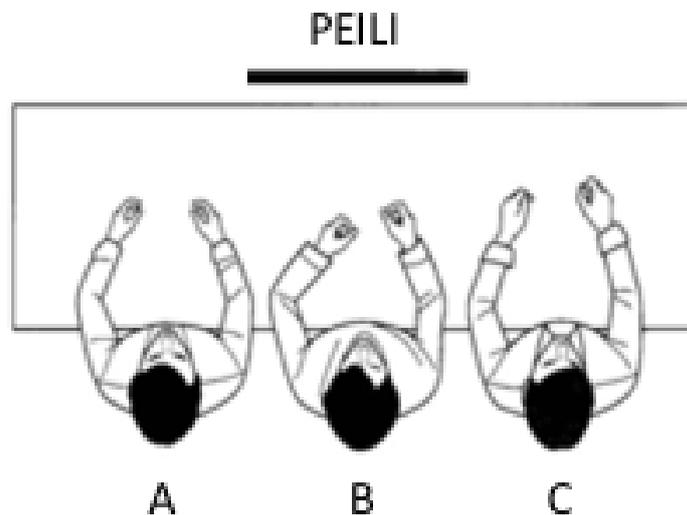


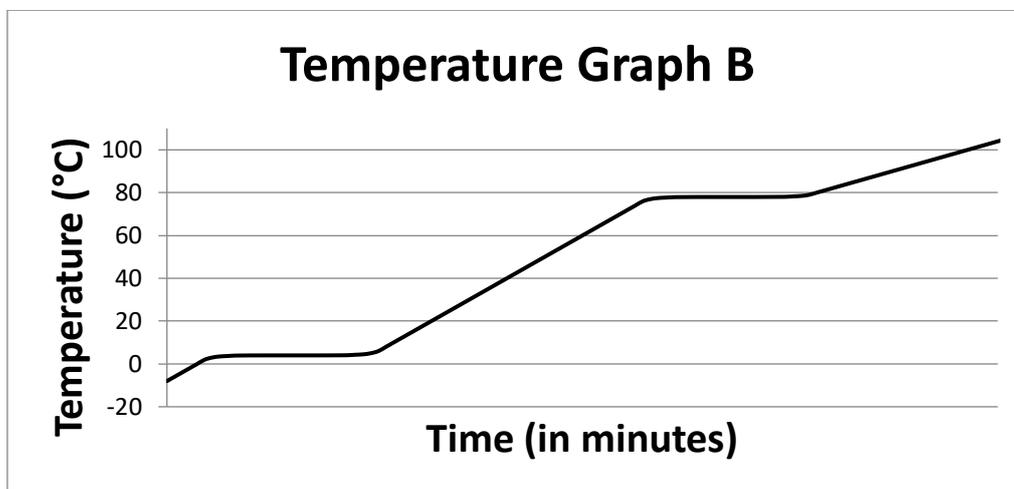
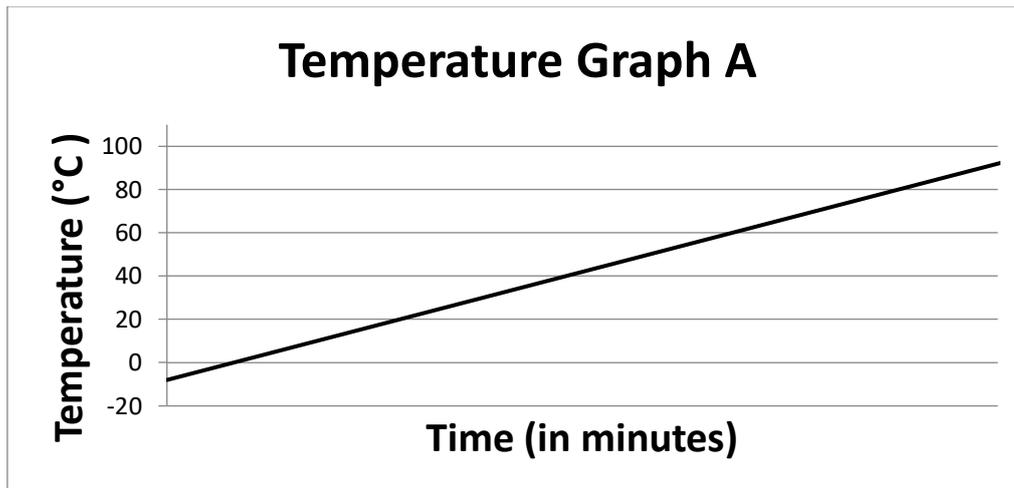
Image used with permission from Hatakka, Saari, Sirviö, Viiri, & Yrjänäinen (2005).

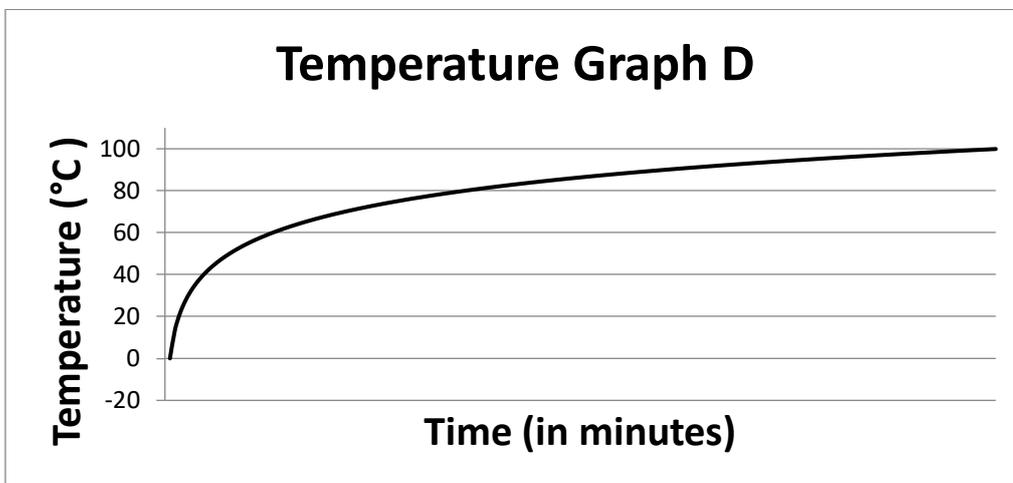
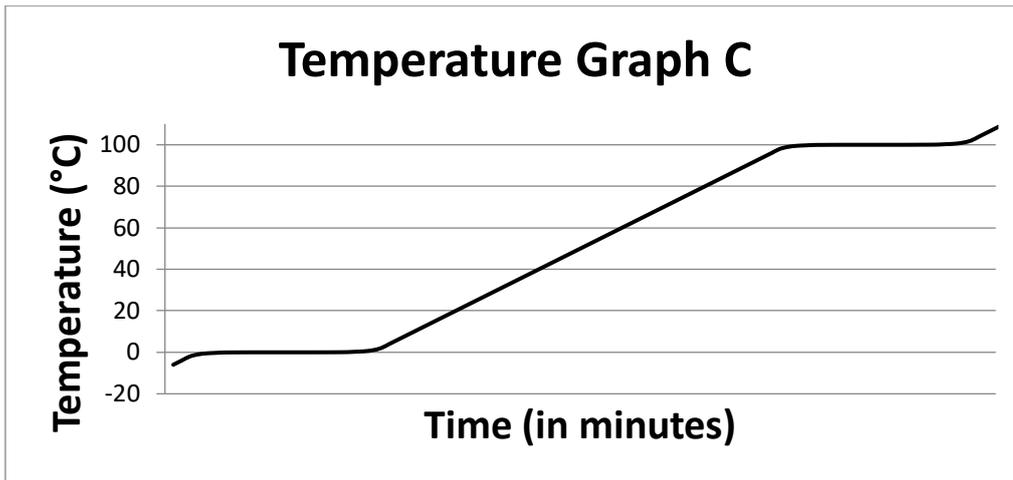
Defend your reasoning! If your group does not reach a consensus, then your group must defend each claim separately.

Lesson 2: Temperature graphs of water

A group of students in a certain school were given the task to decide what kind of a graph would be created when water is heated from ice to steam. The students suggested four different-looking graphs.

1. Decide as a group, if the graph you are given is correct.
2. From the fact cards, choose those which in your opinion support your claim. Each fact card contains a true statement.
3. In the space provided, supply reasoning why you think the fact card supports your claim.





Group worksheet Group: _____

Claim: Our graph _____ is correct/incorrect (circle one).

Fact card _____ supports our claim, because

Fact card _____ supports our claim, because

Fact card _____ supports our claim, because

Fact card _____ supports our claim, because

If you run out of room, you may continue on the back of the paper.

Lesson 2 fact cards

<p>At 0 °C the fixed arrangement of ice breaks down and ice melts to water. <u>Fact Card A</u></p>	<p>At 100 °C the bonds between water molecules break down and water boils into steam. <u>Fact Card B</u></p>
<p>A water-heating device, for example a kettle, functions with constant power, so it constantly uses the same amount of energy for heating. <u>Fact Card C</u></p>	<p>Energy is required to break bonds between molecules. <u>Fact Card D</u></p>
<p>An increasing line on a temperature graph indicates that the temperature of the substance increases. <u>Fact Card E</u></p>	<p>If the temperature graph has a horizontal section, the temperature of the substance does not change. <u>Fact Card F</u></p>
<p>During the time of phase changes, the temperature of a substance does not change. <u>Fact Card G</u></p>	<p>When the bonds between molecules are created or broken, heating energy is not left over for a change in temperature. <u>Fact Card H</u></p>
<p>During the time of a phase change, bonds between molecules are created or broken. <u>Fact Card I</u></p>	<p>As a substance is heated, the molecules of the substance begin to move faster. <u>Fact Card J</u></p>
<p>The density of water is greatest at 4 °C. <u>Fact Card K</u></p>	<p>The boiling point of ethanol is 78 °C. <u>Fact Card L</u></p>

C. EXAMPLE OF ASSESSING ARGUMENTATION

The following example (Table 11) illustrates the process of assessing student argumentation level, using the TAP framework outlined in Appendix A and chapter 4. This episode is classified as Level 4 argumentation, due to the presence of a clear rebuttal present in turn 12. Turns 8 and 10 could possibly be considered a rebuttal against the initial claim in turn 4. Furthermore, turn 20, although it is presented slightly in jest, could be considered a rebuttal which directly addresses the warrant present in turn 19. Joshua's extreme counterexample ("we could say that the people were giants") may appear humorous, but offers a rather convincing argument why the warrant in turn 19 should be disregarded. Most counterclaims and rebuttals throughout this segment have some data and warrants supporting them, exemplifying the high level of argumentation present. If turn 10 or 20 is also considered a rebuttal, then this episode could be classified as Level 5 argumentation, but due to a lack of clear linguistic evidence of opposition, it remains classified as Level 4.

The uncertainty present in the classifications made below underscore reflections made in chapter 6 regarding the reliability of using TAP as an analytical tool. For instance, turn 7 may be classified as data or a warrant, dependent upon how the statement is interpreted.

Table 11. **Sample of assessing argumentation from Don: Lesson 1**
(Note: ellipses indicate omitted irrelevant text)

	Classroom discussion	Argumentation Notes
1	Don: So, Matthew, are you saying that when you look in the mirror you can only see one person at a time?	
2	Matthew: [to teacher] Well, clearly [as in, distinctly].	
3	Don: [neutral] Okay.	
4	Matthew: [to teacher] Or, you can only look at one person at a time	Claim: You can only look at one person at a time
5	Christopher: [Unintelligible]	
6	[Laughter]	

7	Jacob:	Yeah, like if you look at that one person then maybe you haven't even seen the other person yet	Data (or warrant?) supporting claim
8	Joshua:	You can still see at the same time, without moving,	
9	Matthew:	Right, I said that wrong	
10	Joshua:	But you can look wherever, because it didn't say anywhere that you have to be able to look at everything all at the same time.	Turns 8 and 10: counterclaim with data (directions from assignment)
11	Michael:	But that also depends a little on, like, the angle ...	Counterclaim: It depends on the angle
12	Joshua:	But you can also see the angle in the picture	Direct rebuttal with data (using picture) in response to turn 11
13	Michael:	But..	
14	Jacob:	But now, if we consider..	
15	Matthew:	But it would depend on the angle	Restating counterclaim in turn 11
16	Michael:	Yeah if you are 10 meters away then it would look like [unintelligible], then you wouldn't be able to see details. [Teacher has walked to back corner of room to check assignment description]	Data in support of counterclaim (turns 11 & 15)
17	Matthew:	But what if they were..	
18	Joshua:	But they aren't [points at diagram]	Restating rebuttal from turn 12
19	Matthew:	But couldn't we assume something, that if things were one way, then..	Warrant connecting data (turn 16) and claim (turn 11)
20	Joshua:	Like we could say that what if the people were giants. [sarcasm]	Rebuttal (or data?) directly addressing the warrant present in turn 19
21		[laughter]	
