Evaluating the Quality of Dialogical Argumentation in CSCL: Moving Beyond an Analysis of Formal Structure

Douglas Clark, College of Education, Payne 203F, Arizona State University, Tempe, AZ 85287-0911, USA, Douglas.B.Clark@asu.edu,
Victor Sampson, College of Education, Payne 203F, Arizona State University, Tempe, AZ 85287-0911, USA, victor.sampson@asu.edu
Armin Weinberger, Ludwig-Maximilans-Universität, Leopoldstr. 13, 80802 Munich, Germany, armin.weinberger@psy.lmu.de,
Gijsbert Erkens, Research Centre Learning in Interaction, Utrecht University, Heidelberglaan 1, 3584 CS Utrecht, NL, G.Erkens@fss.uu.nl

Abstract: Over the last decade, researchers have developed sophisticated online learning environments to promote argumentative discourse between students. This symposium examines some of the diverse ways researchers have attempted to examine how students engage in argumentation and to assess the effectiveness of CSCL environments in fostering productive argumentation. The papers presented as part of this symposium will focus on four different categories of analytic frameworks: (1) nature and function of contributions within the dialog, (2) nature of reasoning, (3) conceptual quality, and (4) patterns and trajectories of participant interaction. Example analytic frameworks from each category are presented in detail rich enough to illustrate their nature and structure. Synthetic discussions of each category consider the frameworks in light of the underlying theoretical perspectives on argumentation, pedagogical goals, and online environmental structures.

Supporting and Promoting Argumentation in CSCL Environments

Online learning environments that engage and support students in dialogic argumentation provide excellent opportunities for students productively to propose, support, evaluate, critique, and refine ideas. Over the last decade, a number of sophisticated environments have been developed to support students engaging in this type of knowledge-building discourse. Measuring the nature and quality of the dialogic argumentation that takes place within these environments, however, has proven challenging. This is due in part, to the context-specific nature of argumentation (Andriessen, Baker, & Suthers, 2003). As a result, argumentation quality cannot be defined solely on the basis of *what it is;* it must also be defined by *what it is used for, who does it,* and *how it unfolds*. Thus, in order to facilitate research and the development of new CSCL environments, the papers presented as part of this symposium highlight the foci, affordances, and constraints of several different analytic methods for assessing dialogic argumentation that are currently available to researchers. In addition to providing an overview of available methods, a major goal of this symposium is to highlight the benefits and limitations of using the different frameworks for assessing the quality of argumentation in different contexts. The different contexts that we will examine include: (a) the object (or subject) of the discussion, (b) the purpose for engaging in the discussion (e.g., to persuade or to co-construct a better solution), (c) the norms that will govern how participants will distinguish between ideas (e.g., fit with evidence or plausibility), and (d) the medium (the types of tools that have been incorporated into the environment to support argumentation).

Analytic Frameworks Presented

Early work measuring students' argumentation within CSCL environments relied heavily on analytic frameworks that emphasized argument structure and the presence or absence of different structural components of an argument as a way to assess quality (e.g., Toulmin, 1958). However, over the last decade, researchers interested in supporting and promoting argumentation as part of CSCL environments have developed a broad range of methods to assess the nature or quality of dialogic argumentation that better reflect the context-specific nature of argumentation. These methods have enabled researchers to focus on specific aspects of argumentation and to evaluate the impact of specific pedagogical goals or tools as a way to foster productive argumentation in CSCL environments. In order to facilitate the comparison of these analytic frameworks, all of the papers presented as part of this symposium evaluate the same short segment of student argumentation (see Table 1). The students in the example are arguing within a customized asynchronous threaded discussion forum about their interpretations of the data they have collected in an earlier part of the project (Clark & Sampson, 2005). At the heart of their argument is the scientific principle of thermal equilibrium.

Table 1: A short sample of dialogical argumentation to facilitate comparisons.

Individual	Comment
Fran:	I think objects in the same room remain different temperatures because some objects are good conductors and some are bad. This determines how much heat energy is allowed in and out of the object.
Amy:	I disagree; I think all objects in the same room are the same temperature. Conductivity only determines how quickly an object will reach room temperature.
Fran:	No, good conductors let in more heat energy than poor conductors, so objects that let in more heat will get hotter. For example, when I put a piece of metal and a piece of plastic in hot water the metal was a higher temperature after 30 seconds.
Amy:	I guess you're right. Maybe objects are different temperatures.

How should researchers of CSCL environments interpret our student example in terms of argumentation quality? In answering this question, researchers must choose a valid and reliable analytic method that (a) takes into account the context-specific nature of argumentation and (b) is compatible with their theoretical perspectives on argumentation, pedagogical goals, and the structure of their online learning environment. For example, researchers interested in promoting argumentation where individuals attempt to negotiate meaning by "proposing and accepting information in an effort to modify and build on each other's knowledge" are likely to adopt different pedagogical goals and online structures than researchers who are trying to promote argumentation where individuals attempt to "convince each other of their own viewpoint" (Andriessen, Erkens, Van de Laak, Peters, & Coirier, 2003, p. 82). These differences not only influence the nature of the argumentation that takes place between the participants in a CSCL environment but also affect what counts as a productive conversation.

The analytic methods discussed in this symposium were chosen to represent a range of promising approaches for analyzing dialogic argumentation in online learning environments. The selection process focused on each method's capabilities for assessing dialogic argumentation within online environments independent of whether or not the method had been originally developed for application in online or offline environments. As previously mentioned, the categories of analytic focus include (1) nature and function of contributions within the dialog, (2) nature of reasoning, (3) conceptual quality, and (4) patterns and trajectories of participant interaction. Each of the papers presented in this symposium focuses on one of these categories and uses the example of dialogical argumentation provided above to illustrate the constraints and affordances of the different frameworks. Each paper then concludes with a discussion of the suitability of the frameworks for examining the quality of argumentation in different contexts. The purpose of this discussion is not to identify some frameworks as being "better" than others; rather it is intended to provide researchers with a way to choose a framework that is compatible with their theoretical perspectives on argumentation, pedagogical goals, and the structure of their online learning environment.

Analytic Frameworks that Focus on the Nature and Function of Contributions within a Dialog in CSCL Environments

Gijsbert Erkens
Research Centre Learning in Interaction, Utrecht University

Analytic frameworks that focus on the nature and function of participants' contributions examine the types of dialog in which students engage as well as the proportion of conceptually and argumentatively productive dialog. An example of this type of framework has been developed by deVries, Lund, and Baker (2002) to examine ways to promote epistemic dialogue in online learning environments. As defined by deVries, Lund, and Baker, epistemic dialog (1) takes place in a collaborative problem-solving situation, (2) can be characterized as argumentation or explanation, and (3) concerns the knowledge and concepts underlying the problem-solving rather than the execution of problem-solving actions. The analytic framework specifies four main categories (*explanation*, *argumentation*, *problem resolution* and *management*) subdivided in a total of 13 different coding categories. To foster epistemic discourse between students, deVries, Lund, and Baker integrate *structures that promote collaboration*, *asynchronous communication*, *dynamic visualizations*, *socio-cognitive structuring*, and *awareness heightening tools* into the CONNECT environment. In this environment, students work together in order to produce a piece of text that explains a puzzling phenomenon through a process of collaboration and negotiation.

Another example of this type of framework is *Rainbow*. Rainbow, which was developed by Baker, Andriessen, Lund, van Amelsvoort, and Quignard (submitted) to analyze computer-mediated pedagogical debates, comprises seven principal analytic categories. The primary focus is on the epistemic nature of the contributions that students make during collaboration. The framework was developed to allow the researchers to investigate what it means for participants to achieve conceptually deeper levels of interaction. At the most basic level, the Rainbow framework distinguishes between *assignment-related activity* and *outside-activity* (any interaction that is not concerned with carrying out the prescribed task). From there, Rainbow differentiates assignment related activity as either task-focused or non task-focused. Non task-focused activity is categorized as either *social relation* (interaction that is concerned with managing students' social relations with respect to the task) or *interaction management* (interaction concerned with managing the interaction itself). Task-focused activity is categorized as *task management* (management of the progression of the task itself), *opinions* (interaction concerned with expressing opinions with regard to the topic under debate), *argumentation* (expression of arguments and counterarguments directly related to a thesis), and *explore and deepen* (interaction concerned with arguments and counterarguments linked together, their relations, and the meaning of the arguments themselves including elaboration, definition, and extension). Baker and colleagues ground the rationale for each of these seven categories carefully in the research on collaborative learning, task-oriented dialogues, verbal interactions, and argumentation theory.

Janssen, Erkens, Jaspers, & Kanselaar (2006) have developed a *Dialogue Act* coding framework that focuses on the communicative instead of the epistemic nature of the contributions within a dialog. The framework first identifies the communicative function of each utterance typed by the students during their online collaboration and communication. The five main communicative functions include: *argumentative* (indicating a line of argumentation or reasoning), *responsive* (e.g., confirmations, denials, and answers), *informative* (transfer of information), *elicitative* (questions or proposals requiring a response), and *imperative* (commands). The framework specifies twenty-nine different dialogue acts within these five main functions. Seven of the twenty-nine focus on argumentative dialog. Dialogue Acts are recognized by specific 'discourse markers' that indicate the communicative function of the utterance, i.e. the use of the connective 'because' signifying an argumentative reason. The use of discourse markers facilitates the reliability of the framework in hand coding, but offers also the possibility of automatic coding.

Analysis of the Sample Argument

From the perspective of deVries, Lund, and Baker's framework, the example represents desirable epistemic discourse because all four contributions to the discussion can be characterized as either explanation or argumentation. As previously mentioned, de Vries, Lund, and Baker suggest that explanation and argumentation are "potentially powerful mechanisms by which students can collaboratively construct new meaning" (2002, p.64). Similarly, Janssen, Erkens, Jaspers, and Kanselaar's framework and Dialogue Act coding system indicates that the student example represents an extended sequence of argumentation and is therefore of high quality. The student example also represents quality argumentation from the perspective of the Rainbow framework because the example involves conceptual deepening and exploration of the topic.

Constraints and Affordances

Frameworks with a focus on the nature and function of contributions within the dialog focus by definition on ongoing discourse. They are therefore best suited for coding synchronous forums or asynchronous forums rather than environments focusing on the juxtaposition of a small number of crafted responses or the interpretation of dialogic artifacts. That said, however, frameworks such as Rainbow can be adapted to other formats as discussed by Baker and colleagues. Of the three frameworks discussed, de Vries, Lund, and Baker's framework is noteworthy for its consideration of the types of discourse moves that students may make; the Rainbow framework is grounded theoretically and is parsimonious enough to simplify application and analysis. Both focus on the epistemic nature of task-oriented discourse. Janssen, Erkens, Jaspers, and Kanselaar's framework focuses on the communicative nature of task-oriented discourse and offers potential in terms of its automated capabilities, but is inappropriate for judging the quality of contributions. In sum, these frameworks provide different approaches for researchers interested in assessing the nature of student's contributions and the overall effectiveness of online environments designed to encourage substantive discussions about the knowledge and concepts underlying problem solving. An overview of the suitability of these three frameworks for assessing argumentation in different contexts is provided in Table 2.

Table 2: Suitability of the analytic frameworks that focus on the nature and function of contributions

Framework	Nature of the Argumentation: Subject of the Discussion: Well defined problem with one solution	Subject of the Discussion: Complex problem with multiple solutions	Subject of the Discussion: Wicked problems with no right answer	Goal of the Discussion: Reach consensus or persuade others	Goal of the Discussion: Learn more about the topic	Goal of the Discussion: Develop a solution	Rules for Judging Ideas: Empirical	Rules for Judging Ideas: Plausibility or Logic	Rules for Judging Ideas: Moral or ethics	Medium Tools used in the Environment: Easily accessible and accessed information	Medium Tools used in the Environment: Asynchronous communication	Medium Tools used in the Environment: Representations of subject matter	Medium Tools used in the Environment: Dynamic visuals of student arguments	Medium Tools used in the Environment: Socio-cognitive structuring	Medium Tools used in the Environment: Awareness heightening tools
deVries, Lund, & Baker (2002): Epistemic Dialog	••	•••	•••	••	•••	•••	••	••	••	••	••	••	••	•	••
Baker et al. (submitted): Types of Contributions	•••	•••	•••	••	•••	••	••	••	••	••	••	••	••	•	••
Janssen et al. (2006): Dialogue Acts Scoring	••	•••	•••	••	•••	••	•	•	•	••	•••	••	••	•	•••

Note: ••• indicates that the framework is well suited for use in this context, •• indicates that this framework can be used in this context but provides no specific affordances, • indicates that the framework may be inappropriate for this type of context without some modification

Analytic Frameworks that Focus on the Nature of Reasoning during Argumentation in CSCL Environments

Victor Sampson
College of Education, Arizona State University

Analytic frameworks that examine the epistemic nature of students' reasoning focus on the types of reasoning students use to support their claims or to challenge the claims of others. Both Jimenez-Aleixandre, Rodriguez, & Duschl (2000) and Duschl (2000) have developed analytic methods designed to address this question using Walton's (1996) argumentation schemes for presumptive reasoning as a theoretical framework. Walton suggests that dialectical argumentation is grounded in burden of proof, presumption, and plausibility rather than in structural form alone. Walton details twenty-five different argumentation schemes that focus on how presumptions are brought forward in arguments as kinds of premises or as kinds of inferences that link premises to conclusions in a context of argumentative dialog. Examples of these schemes include an argument from evidence to hypothesis (e.g., the data we gathered indicates…) and an argument from analogy (e.g., this is just like…). The function of these schemes is to shift the weight of presumption from one side of a dialog to the other. An opposing voice can then respond with questions or statements that shift the weight of presumption back upon the original participant. Analysis with this type of framework focuses on categorizing the types of reasoning employed within an argument.

Jimenez-Aleixandre, Rodriguez, & Duschl's framework apply a standard Toulmin model (e.g., data, warrants, and qualifiers) to identify instances when students attempt to support their ideas during small group and whole class discussions. Once these instances are identified, they examine *how* students elaborate, reinforce, or oppose the ideas of each other by classifying claims and warrants using epistemic operations based on Walton's categories of presumptive reasoning. Analysis then compares the proportion of these instances to the total about of dialog and the types of epistemic moves that are most often used during the discussion or debate. More recently, Duschl (in press) has developed an innovative way to apply Walton's framework to scientific argumentation in the classroom. Duschl first narrows Walton's twenty-five categories down to the nine categories that they found to have strong relevance to scientific argumentation in the classroom. Distinguishing between even these nine categories, however, proves difficult in coding students' work. Duschl and his group therefore collapsed the nine categories into four categories including *requests for information*, *expert opinion*, *inference*, and *analogy*. They then apply these coding categories at the level of the reasoning sequence, which is approximately at the level of each of the students' comments in our example. Analysis then focuses on the number and proportion of each of these epistemic discourse types in students' discussions.

Analysis of the Sample Argument

The potential benefits of examining the epistemic nature of contributions to a discussion or debate become evident when the student example is analyzed using Jimenez-Aleixandre et al. and Duschl's frameworks. Rather than simply documenting that the students are making claims and supporting their ideas with data, warrants, or qualifiers, these frameworks enable us to identify the nature of their reasoning. For example, Jimenez-Aleixandre et al's framework suggests that these students are attempting to justify their ideas with reasons that focus on causality, consistency, and appeals to instances rather than relying on plausibility or appeals to authority. Similarly, Duschl's framework suggests that the students are relying on desirable epistemic moves such as inferences from evidence to hypothesis (the metal was a higher temperature after 30 seconds) and inferences from cause to effect (conductivity determines how quickly an object will reach room temperature) in order support or refute an idea. The student example therefore represents fairly high quality argumentation from the perspective of these frameworks.

Constraints and Affordances

Frameworks that focus on the epistemic nature of reasoning are designed to provide valuable information about how students determine 'what counts' as warranted knowledge and how students determine which ideas should be accepted, rejected, or modified. Rather than assessing conceptual quality of students' contributions, this focal category revolves around the types of reasoning that students use when they propose, support, evaluate, and challenge ideas. In terms of specific affordances and constraints, Jimenez-Aleixandre, Rodriguez, & Duschl's framework is valuable because it integrates an assessment of reasoning type with structural quality. In practice, however, differentiating between students' epistemic operations can prove difficult, but this framework's consideration of the nature of students' reasoning and argumentation structure may prove particularly fruitful for those interested in scaffolding students as they engage in argumentation. Duschl's framework, in turn, is noteworthy for its distillation and synthesis of Walton's framework into a manageable discipline-specific coding scheme.

Overall, these frameworks (and this categorical focus for analysis) apply well for those interested in helping students to improve their discourse skills, reasoning, and ability to evaluate arguments by helping students learn specific discourse goals (e.g., securing commitments from an opponent or undermining the opponent's argument) and effective strategies to help them meet these goals (e.g., justifying claims with evidence, requiring opponents to justify their claims with evidence). These frameworks also are applicable to almost any type of environment structure because they focus on a core attribute of all argumentation. Generally speaking, they focus on frequency counts so they are better suited to environments supporting free flowing dialog, such as asynchronous and synchronous discussions rather than the micro analysis of smaller segments. One advantage of this categorical focus, however, involves the relative content independence afforded in comparison to frameworks focusing specifically on the conceptual quality of ideas. Frameworks focusing on the epistemic nature of reasoning therefore require little modification when applying them across related topic areas. An overview of the suitability of these two frameworks for assessing argumentation in different contexts is provided in Table 3.

Table 3: Suitability of the analytic frameworks that focus on the nature of reasoning

	Nature of the Argumentation														
	Subject of the Discussion			Goal of the Discussion			Rules for Judging Ideas			Medium Tools used in the Environment					
Framework	Well defined problem with one solution	Complex problem with multiple solutions	Wicked problems with no right answer	Reach consensus or persuade others	Learn more about the topic	Develop a solution	Empirical	Plausibility or Logic	Moral or ethics	Easily accessible and accessed information	Computer mediated communication	Representations of subject matter	Dynamic visuals of student arguments	Socio-cognitive structuring	Awareness heightening tools
Jimenez-Aleixandre et al. (2000): Structure and Nature of Reasoning	••	••	••	••	••	••	•••	•••	••	••	••	••	•	•	•
Duschl (in press): Application of Walton to Dialogic Argumentation	••	••	••	••	••	••	•••	•••	••	••	••	••	•	•	•

Analytic Frameworks that Focus on Conceptual Quality in CSCL Environments

Douglas Clark
College of Education, Arizona State University

Analytic frameworks that focus on *conceptual quality* examine the content or substance of the contributions that are made during a discussion. Clark and Sampson's framework (2005), for example, focuses on analyzing the relationships between levels of opposition that take place during discourse episodes and the nature, conceptual quality, and grounds quality of constituent student contributions. Kuhn and Udell's (2003) framework, on the other hand, focuses on the logical coherence and the relevance of the arguments generated by students as a way to measure the conceptual quality of the ideas proposed by students. The content component is domain-specific, involving specified hierarchical sets of arguments for (pro) and against (con) the topic being debated (which is capitol punishment in their study). The lowest level comprises *Nonjustificatory Arguments*, which have little or no argumentative force. The middle tier comprises *Nonfunctional Arguments*, which focus on tangential aspects of the problem rather than core issues. At the highest level, *Functional Arguments* address core aspects of the problem. This type of focus is especially well-suited for online environments where students' are encouraged to debate and discuss issues without clear "right" or "wrong" answers (such as capital punishment). In addition to these dialogic-oriented frameworks, excellent rhetorical-oriented frameworks by Sandoval and others exist.

Analysis of the Sample Argument

The application of Clark and Sampson's framework to the example of argumentation indicates the discourse is oppositional in nature because it involves a distinct rebuttal against the grounds of an idea as well as a rebuttal against the thesis of an idea. However, in terms of conceptual quality the argumentation is considered poor because the students reach an inaccurate conclusion. Moreover, this episode illustrates how students can distort evidence to match claims. In this example, Fran convinces Amy to abandon her normative idea that objects sitting in the same room are in thermal equilibrium by providing inappropriate evidence in support of a non-normative idea. From the perspective of Kuhn and Udell's framework, we would view the example as exceedingly short but representing quality argumentation. The arguments presented by Fran and Amy are *functional* in terms of conceptual quality, which indicates that these students address key aspects of the problem. Moreover, the discourse moves used by the students in this example heavily emphasize argumentative moves (e.g., challenging the ideas of others) rather than exposition (e.g., proposing or clarifying one's own ideas).

Constraints and Affordances

Overall, the analytic frameworks that focus on conceptual quality are well-suited for online-environments for those interested in the relationship between argumentation and learning. For example, when the pedagogical goal of an online environment is to help students learn how to engage in argumentation (e.g., proposing, justifying, and challenging ideas), the analytic framework can focus on the structure of students' contributions to the discussion and still be sufficient. However, if the goal of the online environment is to provide an opportunity for students to learn from argumentation (e.g., develop a more in-depth understanding of the content that is being discussed), the analytic framework must also be able to examine the normative quality of students' ideas in order to assess the overall effectiveness of the environment. In choosing an analytic framework, researchers must determine the importance of the relationship between the normativity of a comment and the relative time of its contribution. Non-normative content at the onset of dialog followed by increasing normativity by the conclusion of the dialog might represent something entirely different than the reverse trajectory. Kuhn and Udell address the temporal issue by measuring the normativity of students' arguments before and after the dialog, for example, but do not examine the trajectories within the dialog itself.

A focus on conceptual quality of contributions or products fits well with environments that include easily accessible and indexed knowledge bases and enriched representations of focal subject matter because these types of functionalities are often integrated into online environments designed to help students achieve specific content learning goals that are associated with the databases and enriched representations. In addition, environments that integrate asynchronous communication and awareness heightening tools can also benefit from this type of focus. By examining the content of student ideas and how students interact with each other, researchers can better support students as they attempt to negotiate meaning or validate ideas in online environments. One challenge, however, is that rubrics with a focus on normativity become very topic-specific and thus require significant modification for

application across contexts. An overview of the suitability of these two frameworks for assessing argumentation in different contexts is provided in Table 4.

Table 4: Suitability of the analytic frameworks that focus on conceptual quality

Framework	Nature of the Argumentation: Subject of the Discussion: Well defined problem with one solution	Subject of the Discussion: Complex problem with multiple solutions	Subject of the Discussion: Wicked problems with no right answer	Goal of the Discussion: Reach consensus or persuade others	Goal of the Discussion: Learn more about the topic	Goal of the Discussion: Develop a solution	Rules for Judging Ideas: Empirical	Rules for Judging Ideas: Plausibility or Logic	Rules for Judging Ideas: Moral or ethics	Medium Tools used in the Environment: Easily accessible and accessed information	Medium Tools used in the Environment: Computer mediated communication	Medium Tools used in the Environment: Representations of subject matter	Medium Tools used in the Environment: Dynamic visuals of student arguments	Medium Tools used in the Environment: Socio-cognitive structuring	Medium Tools used in the Environment: Awareness heightening tools
Clark & Sampson (2005): Conceptual Quality of Comments	•••	•	•	•••	••	•	•••	•	•	•••	•••	•••	•	•	••
Kuhn & Udell (2003): Argumentation Quality and Types of Comments	••	•••	•	•••	•••	•	••	•••	••	•••	•••	••	•	•	•

Analytic Frameworks that Focus on Patterns and Trajectories of Participant Interaction during Argumentation in CSCL Environments

Armin Weinberger
Knowledge Media Research Center (KMRC), Tübingen

Analytic frameworks focusing on patterns and trajectories of participant interaction consider argumentation as a primarily social activity. Examples of frameworks with that focus are Leitão (2000), Hogan, Nastasi, and Pressley (2000), Baker (2003), and Weinberger and Fischer (2006). Leitão (2000) considers a specific sequence of argumentation to be particularly fruitful for knowledge building. Based on Piaget's (1985) work and his idea of socio-cognitive conflict, Leitão envisions argumentation as a social activity in which students confront each other with opposing views and build knowledge by resolving this conflict in a specific manner. In what Leitão calls a knowledge building cycle, students (1) construct an *argument*, which consists of a position and its justification, (2) construct a *counterargument* in response to the first argument, and (3) create a *reply* that captures the participants' immediate and secondary reactions to the counterargument. Through these patterns of argumentation, the initial arguments may be preserved, revised or withdrawn. Leitão argues that these patterns of argumentation optimally shape the process of social knowledge construction.

Hogan, Nastasi, and Pressley's (2000) framework examines discourse components, interaction patterns, and reasoning complexity. The framework focuses on (1) how students work to improve weak or incomplete ideas, (2) the patterns of verbal interactions that take place between individuals in scientific sense-making activities, and (3) the relationships between discourse patterns and the sophistication of scientific reasoning in discussions. Analysis begins with the assignment of macro-codes to the major modes of a group's discussion at the level of conversational turns. Macro-codes include *Knowledge Construction*, *Logistical*, and *Off-Task*. Micro-codes are then assigned at the level of statement or phrase including *Conceptual*, *Metacognitive*, *Question-Query*, *Nonsubstantive*, and *Other*. Micro-codes include multiple subcategories. Researchers then create discourse maps illustrating the patterns of interactions between students based on these codes. Patterns of interaction include *consensual* (where a student proposes an idea and another student agrees), *responsive* (where a student asks a question and another student answers), and *elaborative* (where students discuss and revise each others ideas). Researchers next assess reasoning complexity and compare this information to the interactional patterns.

Baker's framework examines the standpoints adopted by individuals during argumentation, how ideas change over time, and the pragmatic function of language. The framework focuses on argumentation as a way to facilitate collaborative learning. According to the framework, argumentation transforms the epistemic status of

solutions by establishing relations between the proposed solutions and other knowledge or by promoting the negotiation of new meaning. The epistemic status indicates to what extent solutions are being approved. Arguments strengthen the epistemic status of a solution. Counter-arguments weaken the epistemic status of a solution. As a discursive activity, argumentation establishes relations between possible solutions and other sources of knowledge. As a dialogic activity, argumentation incorporates aspects of formal and pragmatic dialectics. Through the analyses, this framework measures the strengthening and weakening of the epistemic status of various claims as well as the progression of dialectic moves.

Weinberger and Fischer's (2006) framework examines the process through which knowledge is constructed as students engage in argumentation in online environments. Their framework assesses argumentation along four independent dimensions. The *participation dimension* analyzes the amount of participation by each student and the heterogeneity of participation within the learning group. The *epistemic dimension* identifies how and what theoretical concepts students use in their argumentation them in terms of the environment's learning goals. On the *formal argumentative dimension*, Weinberger and Fischer analyze the construction of single arguments through a simplified version of Toulmin's scheme (1958) as well as through the argumentation sequences outlined in Leitão's (2000) work. Finally, on the *dimension of social modes of co-construction,* Weinberger and Fischer analyze the transactivity of students' arguments (Teasley, 1997), i.e. to what extent students refer to the arguments and operate on the reasoning of their learning partners. Different ways to build consensus correspond with different degrees of transactivity. Students can establish consensus by agreeing with the ideas proposed by their peers (relatively low transactivity), integrating peers' arguments into their own line of argumentation (relatively high transactivity), or by engaging in a conflict-oriented negotiation of different perspectives (relatively high transactivity).

Analysis of the Sample Argument

From the perspective of Leitão's framework, our student example represents a complete knowledge building cycle. The episode begins with Fran contributing her initial argument. Amy then counters by bringing the truth of the claim into question. Fran replies by dismissing Amy's counter argument which enables Fran to preserve her initial viewpoint. In this case, Amy accepts Fran's ideas and withdraws her initial viewpoint. From Leitão's perspective, both this type of outcome and outcomes that result in a revised argument represent successful outcomes of argumentation. Hogan, Nastasi, and Pressley's framework would describe the sample argument as an *elaborative* interaction pattern. They suggest that elaborative interaction patterns are characteristic of quality argumentation because they prolong discussions and lead to higher levels of reasoning. Although there is no elaboration present, the student example's macro-code represents Knowledge Construction from the perspective of this framework. The example also represents fairly high quality argumentation from the perspective of Baker's framework. Although brief, the discourse changes the epistemic status of Idea A (objects remain different temperatures) and Idea C (objects become the same temperature) which indicates productive argumentation. Applying Weinberger and Fischer's framework shows that the learners participate homogeneously (*participation dimension*). With respect to the *epistemic dimension*, both Fran and Amy engage in on-task talk and construct relations between the target conceptual space (rather than prior knowledge) and the problem space. However, some of the concepts are being applied inadequately. On the *formal argumentative dimension*, Amy and Fran build relatively complete arguments and argumentation sequences. Finally, on the *social modes of co-construction dimension,* Amy and Fran clearly engage in conflict-oriented consensus building as they refer to each other's contributions and attempt to negotiate meaning.

Constraints and Affordances

This analytic category increases the unit of analysis from an individual comment or fragment to an entire knowledge building cycle. As such it allows us to focus on the actual processes of co-construction of knowledge rather than focusing on frequency counts of elements that correlate to desirable interaction. Leitão, for example, emphasizes the social nature of knowledge building as opposed to online contexts in which students hardly interact with the activities of their learning partners (e.g., by composing elaborate, essay-like replies in discussion boards). This approach thus emphasizes the coherence of argumentative talk between students. One interesting dichotomy, however, involves the presence or absence of a pedagogical goal state within the framework to inform the development of practice. In other words, does the framework provide a road map for instruction in terms of desirable student practice? For example, Baker's analytic framework provides ways to track the evolution and change in status of the ideas discussed by students and how (or if) they are challenged, but the framework provides us less concrete guidance for instruction. What do we want students to know or to be able to do? Other frameworks are more prescriptive in this regard. Weinberger and Fischer (2006) have applied different kinds of computer-

supported collaboration scripts to successfully facilitate learners' interaction with respect to the single dimensions of their framework. Their line of research indicates that especially scripts that facilitate transactivity of learners in CSCL environments, have also facilitated individual knowledge acquisition (Weinberger, Stegmann, Fischer, & Mandl, in press).

This type of analytic focus may be applied across most collaborative online argumentation environments independent of environment structure or the nature of the artifacts created, because this analysis can focus at microgenetic scales as well as broad scales. Increased complexity of application accompanies this increased power, however. The challenge of this analytic category manifests itself in terms of increased amount and complexity of work required to reliably apply these types of analyses across larger samples. An overview of the suitability of these four frameworks for assessing argumentation in different contexts is provided in Table 5.

Table 5: Suitability of the analytic frameworks that focus on patterns and trajectories of participant interaction

	Nature of the Argumentation														
	Subject of the Discussion			Goal of the Discussion			Rules for Judging Ideas			Medium Tools used in the Environment					
Framework	Well defined problem with one solution	Complex problem with multiple solutions	Wicked problems with no right answer	Reach consensus or persuade others	Learn more about the topic	Develop a solution	Empirical	Plausibility or Logic	Moral or ethics	Easily accessible and accessed information	Computer mediated communication	Representations of subject matter	Dynamic visuals of student arguments	Socio-cognitive structuring	Awareness heightening tools
Leitão (2000): Knowledge Building	••	•••	•••	•••	•••	•••	••	••	••	••	•••	••	•	•	•
Hogan et al. (2000): Interactional Patterns	•••	•••	••	•••	••	••	••	••	••	••	•••	••	•	•	•
Baker (2003): How ideas change	••	•••	•••	•••	•	•••	••	••	••	••	•••	••	•	•	•
Weinberger & Fischer (2006): Co-construction of knowledge	••	•••	••	•••	•••	•••	••	•	•	••	•••	••	•	•••	•

Synthesis

In this symposium we consider several frameworks for analyzing dialogic argumentation in online learning environments. These analytic frameworks vary significantly in terms of their focus and affordances. (Each presenter in our symposium will go into greater detail about each focal category.) Although most of the frameworks discussed here would assess the student example as representing fairly desirable argumentative discourse, they each do so for very different reasons. In building online environments to support argumentation, researchers therefore need to be clear and specific in terms of their theoretical commitments about argumentation and the pedagogical goals they wish to foster (and concomitantly measure) through the environment. These decisions are foundational in the subsequent adoption or development of an appropriate analytic framework.

Another issue that becomes apparent when reviewing these frameworks involves the potential to synergistically integrate multiple categories of analytic focus within a single framework. Although each paper in this symposium examines a single focal category, all of the frameworks consider additional foci beyond their focal categories. By coordinating the analyses of multiple categories simultaneously, we can potentially learn more about students' performance in terms of each individual category. Integrating other analyses within the analysis of the patterns and trajectories of participant interaction seems the most promising. Most of the other categories of analytic focus correlate frequency counts of various components as correlational markers for argumentation quality. Careful tracking of participant interaction and the evolution of ideas would align our analyses more directly, and therefore potentially more validly, with the processes of argumentation we wish to foster. The challenge, of course, rests in the increased accompanying complexity of conducting such analyses.

Online learning environments offer strong affordances for grappling with these challenges and realizing these gains. Online learning environments incorporate the potential to closely log students' actions and interactions. As we develop technologies to more carefully track and analyze student data, we will have the capability to track interactions and quality more accurately in real time. Based on this information, we could then modify supports for argumentation in real time. Dönmez, Rosé, Stegmann, Weinberger, and Fischer (2005) have made early progress in this regard by harnessing latent text analysis technology to score the quality of students' argumentation products. Similarly, the Multiple Protocol Episode Analysis system (Janssen, Erkens, Jaspers, & Kanselaar, 2006) can score extended dialogs and messages using a complex rules system instantaneously. In both of these examples, analyses were not conducted in real time, but the potential is staggering. As we develop more sophisticated methods for analyzing argumentation, we should therefore continue to monitor the possibilities for embedding these analytic methods directly as real time functionality within online learning environments. These analytic models would therefore not only improve our research capabilities but also facilitate higher levels of interactivity and customized scaffolding for students engaging in argumentation in our schools. The discussion at the conclusion of our symposium will also consider the implications of the frameworks beyond research in terms of these other applications.

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