Argumentative Knowledge Construction in CSCL

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Abstract: Knowing how to argue is a prerequisite to participation in scientific discourse. In argumentative knowledge construction, learners collaboratively construct and engage in arguments with the goal of learning to argue within a domain. Students have difficulties, however, constructing and evaluating arguments. Computer-supported collaborative learning (CSCL) attempts to address these difficulties by providing students with additional resources and tools to visualize and guide their argumentation. This symposium presents results from empirical studies on facilitating and analyzing argumentative knowledge construction in CSCL. These studies assess the structural and conceptual quality of learners' arguments; provide sequential analyses of how learners exchange arguments in discourse, and investigate the relationship between cognitive processes of learners and the construction of arguments in discourse.

Argumentative Knowledge Construction in CSCL

Current research suggests that *argumentative knowledge* is an important component of critical thinking and decision-making in everyday situations (Kuhn, 1991) and understanding and participating in scientific discourse (Driver, Newton, & Osborne, 2000; Sandoval & Millwood, 2005). The term argumentative knowledge refers to an understanding of how to examine and evaluate data and then construct arguments for and against a course of action or point of view. Students in secondary schools and universities, however, have difficulties constructing reasoned arguments and evaluating the arguments of others (Duschl & Osborne, 2002; Kuhn, 1991). This lack of argumentative knowledge has fuelled research on how to facilitate learners' construction of argumentative knowledge (Perkins, 1989; Kuhn, Shaw, & Felton, 1997).

In *argumentative knowledge construction* learners engage in argumentation in order to learn how to argue within a domain (Kuhn et al, 1997). But engaging students in argumentative knowledge construction raises a paradox: participating in argumentative discourse with the goal to learn how to argue within a domain may be the best way to develop students' argumentative knowledge, but students' understanding of how to construct and evaluate arguments may interfere with this process. To address this concern, a number of computer-supported collaborative learning (CSCL) environments have been designed to support students as they engage in argumentative knowledge construction.

Current research suggests that CSCL environments have a number of advantages over traditional forms of classroom instruction for facilitating the process of argumentative knowledge construction (Andriessen, Baker, & Suthers, 2003; Joiner & Jones, 2003; Kirschner, Buckingham Shum, & Carr; 2003; Marttunen & Laurinen, 2001; Weinberger & Fischer, 2006). First, CSCL encourages peer interaction, which has been successfully drawn upon to facilitate argumentative knowledge construction (Kuhn et al., 1997; Schwarz, Neuman, Gil, & Ilya, 2003). Second, in CSCL environments, asynchronous communication can be used as a way to encourage learners to construct and (re-)evaluate arguments by providing them with as much time as they require when generating comments or responding to the comments of others (Joiner & Jones, 2003; Pea, 1994). Third, CSCL environments can implement special tools and scaffolds to guide learners in effective argumentative knowledge construction. For example, Kirschner et al. (2003) developed a tool that enables learners to visualize single arguments and sequences of argumentation while Jermann and Dillenbourg (2003) developed tools that script and scaffold learners' interaction by assigning and prompting roles for the learners. Taken together, this body of research suggests that computer-supported collaborative learning environments can facilitate the development of argumentative knowledge.

Research Presented

Building upon this research, this symposium provides new insights into the teaching and learning of argumentation. The papers (a) discuss ways to provide students with additional resources and tools to visualize and guide their argumentation, (b) present results of empirical studies on different facets of facilitating and analyzing argumentative knowledge construction in CSCL, and (c) introduce new ways to assess the structural and conceptual quality of learners' arguments and their understanding of argumentation. Taken together, these studies emphasize that argumentation is more than a cognitive activity of coordinating data around claims; it is also a social practice of persuasion and collaborative knowledge construction.

Visualizing participation to facilitate argumentation

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Introduction and Theoretical Background

Participation and equality of participation are important prerequisites for effective and beneficial collaborative learning (Cohen, 1994; Weinberger & Fischer, 2006). Unfortunately, students do not always participate equally in argumentative discussions in CSCL environments (Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003). However, Michinov and Primois (2005) and Zumbach, Hillers, and Reimann (2004) suggest that providing a way for students to visualize levels of participation in a discussion can stimulate participation and thus facilitate argumentative knowledge construction. Providing a visualization of students' participation creates opportunities for social evaluation and constitutes a possible motivational incentive to increase group members' participation (Shepperd, 1993). Providing a visualization of participation also raises students' awareness of the constructive, communicative, and social processes taking place during argumentative discussion (Kreijns, 2004).

In order to investigate the degree to which visualization of participation stimulates group members' participation rates and facilitates argumentative knowledge construction, a new tool was added to an existing CSCL-environment (Virtual Collaborative Research Institute/VCRI, Jaspers, Broeken, & Erkens, 2004). This *Participation Tool* visualizes the contributions of each group member to the group's online communication (see Figure 1). Each student is represented by a sphere. The distance of a sphere to the group center indicates the number of messages sent by the student; whereas the size of the sphere indicates the average length of messages. The Participation Tool therefore visually clarifies the quantity and the homogeneity/heterogeneity of participation. An earlier study demonstrated that, compared to control group students, students with access to the Participation Tool (treatment group students) participated more actively during online collaboration (more and longer utterances) and engaged more deeply in the coordination of social activities (Janssen, Erkens, Kanselaar, & Jaspers, in press). These findings raise two new questions. (1) Is participation a sufficient condition for effective argumentative knowledge construction? (2) Does improving participation also improve the quality of argumentative knowledge construction?

Methods and Data Analysis

We conducted sequential analyses of the arguments group members constructed. In lag-sequential analysis (Bakeman & Gottman, 1997; Wampold, 1992), the transition patterns between the arguments in a discourse protocol can be statistically tested on different intervals (lags) between the events. The computer program *Multiple Episode Protocol Analysis* (MEPA), which was developed at Utrecht University, is used for sequential analysis and coding of argumentative discussions of collaborating students. The chat protocols of 52 treatment group students (17 groups) and 17 control group students (5 groups) were analyzed. These students (age 16-18) worked for eight lessons in groups of three or four students on an inquiry-based group task as part of their history curriculum. The communicative function of each chat utterance was coded into 'dialogue acts'. The dialogue acts were organized into 28 sub-categories within five main categories of communicative function: *argumentative* (indicating a line of argumentation or reasoning), *responsive* (answers to questions and proposals), *informative* (transfer of information), *elicitative* (questions or proposals requiring a response), and *imperative* (commands).

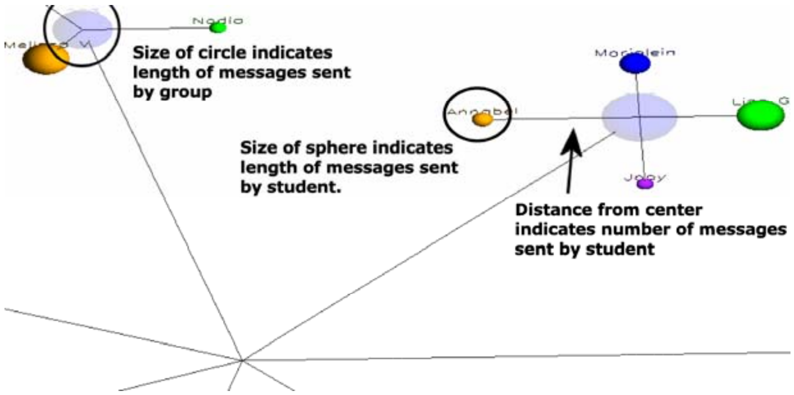

Figure 1. Screenshot of the Participation Tool

Results and Conclusions

The results of our analyses show that Participation Tool students engage in a higher number and frequency of argumentative dialogue acts. This increase is due to an increase in counter arguments and conditional arguments. Furthermore, results of sequential analyses indicate that treatment groups use different argumentation patterns compared to control groups. More specifically, treatment groups engage in longer sequences of argumentation. Finally, sequential analysis indicates that successful groups (those who write better reports) use different argumentation patterns than less successful groups. Not only does the Participation Tool help students construct arguments, it also helps students construct arguments in specific cycles with their group members. In conclusion, visualizing participation appears to facilitate argumentative knowledge construction by raising students' awareness the manner in which they are collaborating, thereby stimulating them to construct more arguments and engage in different argumentation patterns. In our future research, we will try to facilitate argumentative knowledge construction further by visualizing argumentative discourse of participants during online collaboration.

Scripting Online Discussions: Effects on Argumentative Discourse, Cognitive Processes, and Knowledge Acquisition

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Introduction and Theoretical Background

A central goal of university education is to develop students' ability to understand and participate in argumentative discourse within a specific field of study. In argumentative knowledge construction, learners are believed to expand their *argumentative* and *domain-specific knowledge* on a cognitive level by constructing arguments and counterarguments as they solve a complex problem case in their domain (Andriessen, et al., 2003; Marttunen & Laurinen, 2001; Weinberger & Fischer, 2006). Learners, however, often do not know how to engage in argumentative discussions (Kuhn, 1991).

Recently, *computer-supported collaboration scripts* were developed to facilitate processes of argumentative knowledge construction (Jermann & Dillenbourg, 2003). Based on O'Donnell's (1999) scripted cooperation approach, computer-supported collaboration scripts pre-structure roles and activities, e.g., by providing text prompts that guide learners to engage in specific interaction patterns (Baker & Lund, 1997; Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2002). We hypothesize that scripts for argumentative knowledge construction can guide learners as they construct arguments and in so doing, their argumentative knowledge can be improved on a cognitive level. Results so far show that scripts can facilitate specific discourse activities, such as epistemic activities that aim to construct knowledge, but this does not always contribute to the facilitation of knowledge acquisition (Mäkitalo, Weinberger, Häkkinen, Järvelä, & Fischer, 2005). Some scripts appear to hinder cognitive processes by oversimplifying the learning task (Reiser, 2002; Weinberger, Ertl, Fischer, & Mandl, 2005). However, little is known about the relationship between the construction of arguments in discourse and the cognitive activities of individual learners. If scripts facilitate the construction of arguments in discourse, do they also facilitate the cognitive elaboration of knowledge?

Methods and Data Analysis

We conducted two experimental studies with different foci of analysis in a CSCL environment with groups of three students enrolled in Educational Science. In the first study (n = 60), we analyzed the effects of a computer-supported collaboration script that aimed to support the construction of single arguments on the processes and outcomes of argumentative knowledge construction (see figure 3) based on the written online discussions of the learners with regard to the epistemic quality of arguments (i.e., the extent the arguments contributed to solving the learning task by applying specific theoretical concepts) and the formal argumentative quality of arguments (i.e., the extent the arguments included claims, warrants, data, and qualifiers). In the second study (n = 54) with the script for the construction of single arguments (vs. control) we also analyzed the cognitive processes of argumentative knowledge construction based on think-aloud protocols during the text-based collaboration, regarding the level and focus of elaboration, as well as their relation to the respective discourse activities.

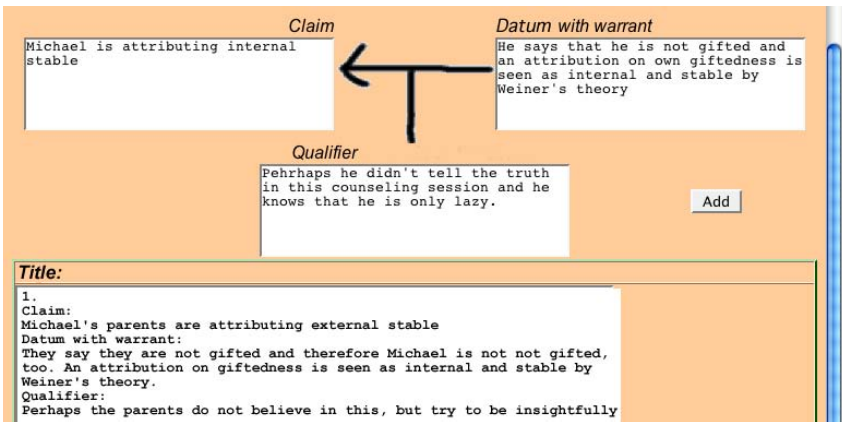

Figure 3: Input mask remodeled by a script for constructing single arguments

Results and Conclusions

Results of the first study show that computer-supported scripts can facilitate specific processes and outcomes of argumentative knowledge construction. Learners with scripts construct arguments of higher structural quality and acquire more argumentative knowledge than learners without scripts. Results of the second study show that constructing formally adequate arguments in discourse fosters cognitive processes and acquisition of argumentative knowledge. The acquisition of domain-specific knowledge, however, depends on the epistemic quality of arguments constructed in online discussions and the focus of elaboration. Learners' activities on a cognitive level are generally closely related to discourse activities as well as to individual knowledge acquisition. Learners who acquire more domain-specific knowledge than average spend more effort to cognitively elaborate single arguments rather than to construct many arguments with little cognitive elaboration.

Evaluating Argumentation in Science: New Assessment Tools

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Introduction and Theoretical Background

Researchers have developed several different methods to investigate argumentative discourse. To date, most of these investigations have relied heavily on Toulmin's (1958) model of argument structure in one way or another (e.g., Erduran, Osborne & Simon, 2004). In these studies, emphasis is placed on the identification of the structural features of arguments (e.g., claims, data, warrants, backings, and rebuttals). Such approaches seek to identify the absence or presence of the components of argument and use this information to assess argumentation quality. These types of structural analyses of student arguments have contributed a great deal to our understanding of how students assimilate the desired practices of argumentation and provide a great deal of information about the form and type of reasoning that students use when they construct arguments based on their everyday experiences (Driver et al., 2000). However, they provide little information about (a) the types of argumentative knowledge and skill young people bring with them to their science classrooms, (b) how students ideas about the nature of science influence the ways they participate in argumentative discussions, and (c) how students' conceptual ideas about the subject matter change as a result of participation in dialogic argumentation.

The Instruments

Specifically, this study presents (a) an analytic scheme for assessing argumentative discourse in asynchronous online environments that extends beyond the structural analysis that has been the focus of much argumentation research, (b) *The Nature of Science as Argument Questionnaire* (NSAAQ) which evaluates students' epistemological commitments related to argumentation, and (c) an *Argumentation in Science Rating Task* (ASRT) which evaluates the criteria used by students for evaluating the quality of arguments and argumentative discourse.

An analytic scheme for assessing argumentative discourse in asynchronous online environments. Our scheme first scores the individual comments in terms of structural operation, grounds quality, and conceptual quality. Each comment is coded in the context of its parent comment. Structural operation is a categorical (nominal) code representing the comment's role or intended role in a co-constructed dialogic argument. Sample structural operation categories include: claim, rebuttal against grounds, organization of participation, and off-task comments. Grounds Quality is an ordinal code with four levels representing the quality of grounds included with a comment: no grounds (level 0), explanation only (level 1), explanation with evidence (level 2), and explanation that coordinates evidence (level 3). Conceptual Quality is an ordinal code with four levels representing the conceptual quality of the scientific subject matter including non-normative (level 0), transitional (level 1), normative (level 2), and nuanced (level 3) use of content. After coding the individual comments, the discussion is parsed into discourse episodes based on the second-order comments. This is a completely mechanical process based on responses to the initial seed claims. We then assign a structural quality code to each discourse episode based on the structural operation codes of the constituent comments. The structural quality code is an ordinal code with six levels measuring the opposition within the episode from a structural (not conceptual) perspective. These structural quality levels include non-oppositional episodes (level 0), argumentation with claims or counterclaims but no grounds or rebuttals (level 1), argumentation with claims or counterclaims and grounds but no rebuttals (level 2), argumentation with grounds and a single rebuttal (level 3), argumentation with multiple rebuttals (level 4), and argumentation with multiple rebuttals and at least one rebuttal against grounds (level 5).

The Nature of Science as Argument Questionnaire (NSAAQ). This instrument was developed in order to identify important aspects of an individual's epistemological beliefs related to the role argumentation plays in the generation and evaluation of scientific knowledge. We hypothesize that the difficulties students have engaging in scienitifc argumentation that are so well documented in the literature may be explained, in part, by exmining the epistemological commitments they have about the nature and limits of scientific knowledge. If students do not share the same epistemological committments that guide and constrain scientific argumentation within the scientific community, then it is unlikely that students will engage in scientific argumentation in a way that reflects the norms of the scientific community. The NSAAQ is designed to measure and characterize an individual's epistemological beliefs regarding: (a) the nature of scientific knowledge; (b) the methods used to generate scientific knowledge; (c) how scientific knowledge should be evaluated; and (d) whether or not science is a social and cultural practice. The NSAAQ consists of 26 *contrasting alternatives* items (see figure 4) divided into four subsclaes. The validity and reliability of the NSAAQ was examined using a methodological framework proposed by Gubba and Lincoln (1990) who suggest that a credible instrument must have strong construct and criterion validity in addition to being reliable.

Viewpoint A	A not B	A > B	A = B	B > A	B not A	Viewpoint B
Science is best described as a process of exploration and experiment.	1	2	3	4	5	Science is best described as a process of explanation and argument.

Figure 4. An example of a NSAAQ contrasting alternatives item

The Argumentation in Science Rating Task (ASRT). Scientists construct arguments by relating the evidence they have gathered to the conclusions they reach through the use of warrants and backings (Erduran, Simon, & Osborne, 2004). Scientists also challenge the acceptability or validity of the claims proposed by other scientists by challenging the evidence, warrants, and backings that were used to justify a given conclusion (Latour & Woolgar, 1986; Longino, 1990). Therefore, the ASRT was developed in order to assess the criteria used by students for evaluating the quality of arguments and the quality of challenges to arguments used during argumentative discourse. The ASRT consists of six items, three that focus on the quality of argument that can be used to justify a claim and three that focus on the quality of a challenge to an argument. For each item, individuals are asked to rank six arguments or six challenges to an argument in terms of quality. An example of an ASRT is shown in figure 5. The validity and reliability of the ASRT was examined using the same methodological framework that was used to develop and validate the NSAAQ.

Claim: Objects that are in the same room are the same temperature even though they feel different because…	**Your Ranking**
…when we measured the temperature of the table, it was 23.4^{O}C, the metal chair leg was 23.1^{O}C, and the computer keyboard was 23.6^{O}C.	________
…good conductors feel different than poor conductors even though they are the same temperature.	________
…objects that are in the same environment gain or lose heat energy until everything is the same temperature. Our data form the lab proves that point: the mouse pad and plastic desk were both 23^{O}C.	________
…objects will release and hold different amounts of heat energy depending on how good of an insulator or conductor it is.	________
…our textbook says that all objects in the same room will eventually reach the same temperature.	________
…we measured the temperature of the wooden table and the chair leg and they were both 23^{O}C even though the metal chair leg feels colder. If the metal chair leg was actually colder it would have been a lower temperature when we compared it to the temperature of the table.	________

Figure 5. An example of an ASRT item

Results and Conclusions

The inter-rater reliability of argumentative coding scheme, which is designed to provide a reliable method to parse, code, and analyze student argumentation in asynchronous online forums based on structure, grounds, and conceptual quality of individual comments, is 93% for structural operation, 94% for conceptual quality, and 95% for grounds quality. Taken together, these statistics indicate that the coding scheme is reliable despite its complexity. The construct validity of the NSAAQ and the ASRT has been established by assessing the content, face, translation, and discriment validity of the instruments. The criterion validity of the NSAAQ and ASRT was assessed by examining the convergent and concurrent validity of the instruments based on their psychometric properties. Hence, these instruments are likely to give data from which valid conclusions can be drawn. This means that the NSAAQ and the ASRT are likely to be useful tools for researchers who wish to measure the degree in which an individual's epistemological beliefs reflect those of the scientific community and the criteria used by students for evaluating the quality of arguments and argumentative discourse.

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