Analyzing collaborative learning: Multiple approaches to understanding processes and outcomes

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Abstract: It is important to consider collaborative processes from multiple perspectives because collaborative learning environments are complex, often requiring multiple methodological approaches to understand their different aspects (Hmelo-Silver, 2003). Collaborative learning is the subject of study in a wide variety of disciplines such as developmental psychology (e.g., socio-cognitive conflict), social psychology (person perception, motivation, group processes), sociology (status, power and authority), cognitive psychology (how learning occurs, learning outcomes) and sociocultural perspectives (cultural influence on interaction, mediation of learning). These different perspectives suggest that a variety of methodological tools are needed to understand collaborative interactions. Each of the papers in this symposium explores one or more methods for examining the quality of collaborative interactions. The discussion will focus on criteria for good analyses of collaborative work as well as strengths and limitations of various methods.

Collaborative learning environments are complex beasts, often requiring multiple methodological approaches to understanding interactions (Hmelo-Silver, 2003). Like Rummel & Spada, 2004, we argue that it is important to consider collaborative processes from multiple perspectives. Collaborative learning is the subject of study in a wide variety of disciplines such as developmental psychology (e.g., socio-cognitive conflict), social psychology (person perception, motivation, group processes), sociology (status, power and authority), cognitive psychology (how learning occurs, learning outcomes) and sociocultural perspectives (cultural influence on interaction, mediation of learning). These different perspectives suggest that a variety of methodological tools are needed to understand collaborative interactions. We consider methodological tools that examine the quality of processes and trajectories of interactions.

Two commonly used approaches for analyzing data are to classify individual learners' statements and to provide descriptive, qualitative analyses of transcripts. Researchers using the first approach have used a diverse range of approaches to classifying individual students' statements, ranging from classifying cognitive strategies (such as elaboration or explanation) used by individual students (Webb & Farivar, 2000) to classifying moves such as giving or receiving help. This general approach provides information about individuals' performance within groups but does not provide a picture of the overall structure or flow of the group discourse or how individuals contribute to this overall structure or flow. Researchers using the second, more descriptive approach have provided rich pictures of interactions, but this is not a method that is well suited for making systematic comparisons across different groups or discussions.

Each of the papers in this symposium explores one or more methods for examining the quality of collaborative interactions. Chinn discusses five different approaches to analyzing argumentative discourse, noting the strengths and limitations of each approach for generating both qualitative and quantitative understandings of discourse quality. O'Donnell examines how individual contributions during dialogue can be traced in terms of their influence on others. Hmelo-Silver, Chernobilsky, and Mastov discuss representations that can aid in the interpretation of complex collaborative learning environments. Erkens and Janssen discuss how the coding of dialogue acts can be made more tractable through reliable and valid automated coding mechanisms.

Brigid Barron will comment on the presentations. The discussions among panelists and the discussant will include a focus on criteria for good analyses of collaborative work. Examining the range of methods that we have collectively used to examine the quality of group interactions, we will discuss criteria that should be met by methodological tools that succeed at capturing the richness of group interaction and the limitations of the different approaches.

Assessing the Quality of Collaborative Argumentation

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Introduction

One important type of collaborative discourse is argumentation. Many tasks designed to develop students' inquiry skills have engaged collaborative groups of students in argumentation (see Duschl & Osborne, 2002). Hence, it is important to develop effective methods of assessing the quality of argumentation in collaborative groups.

Criteria for developing measures of collaborative argumentation

Measures of argumentation should provide insights into both the quality of the *overall group* argumentation and the quality of *individual* contributions to the group. They should illuminate the *structure* of the discourse and the *content* of the discourse. And they should ideally provide both *qualitative* and *quantitative* windows into discourse quality.

Measuring features of argumentation

I discuss five methods that have been used to analyze collaborative argumentation. I discuss these methods in the context of a study with seventh graders who were discussing epidemiological studies they had read about.

Coding *speech acts* is a very common way of measuring aspects of many forms of discourse, including argumentative discourse (e.g., Resnick et al., 1993). When applied to argumentation, speech act analysis involves classifying statements into functional categories such as claims, supporting reasons, qualifiers, counterarguments, rebuttals, concessions, and so on. Speech act analysis of argumentation provides a one-dimensional picture of the distribution of speech acts in a group and in individuals. It does not provide insights into the structure or the content of discussions.

More *specific reasoning strategies* can also be coded. For instance, in the seventh graders' discussions, we code the use of particular reasoning strategies in the discussion such as weighing sample size, evaluating the adequacy of comparison groups, and examining whether measurements are biased. Unlike speech act analyses, analyses of specific reasoning strategies can distinguish between good reasons (e.g., arguing that a conclusion should be rejected because the methodology of a study is flawed) and poor reasons (e.g., arguing that West Nile disease is contagious on the basis of a single person's impressions).

The two measures discussed so far do not capture the structure of discourse. In contrast, an adaptation of Toulmin's (1958) well-known method of diagramming arguments allows researchers to represent argumentation as *argument networks* (see Chinn & Anderson, 1998). The figures below shows the structural outlines of a simple (left) and complex (right) argument network. Rectangles represent claims made. Reasons for claims are in ovals connected to claims by arrows. Reasons given to support or contradict other reasons create deeper layers within the network. Chinn, O'Donnell, and Jinks (2000) showed that students in groups of fifth graders who participated in scientific discussions learned more when argument networks were more complex than when argument networks were simpler.

Figure 1. Prototypical simple argument network

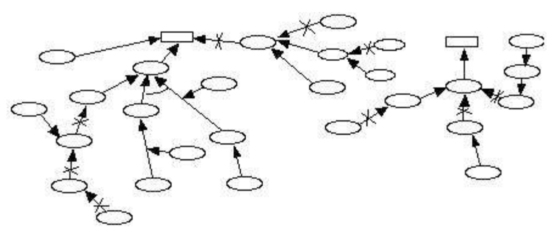

Figure 2. Prototypical complex argument network

Argument networks are like speech act analyses in that they show the presence of claims and supporting reasons, but they go further in that they capture the structure of the discussion. Argument networks can be used to generate quantitative measures of both the quality of the group discussion and the quality of each individual's contribution (Chinn & Anderson, 1998). Argument networks do not, however, provide any information about the content of the discussion. The complex argument network above could equally represent argumentation with strong reasons and evidence and argumentation marked by sophistry.

Analysis of *argument schemas* is a fourth approach that can be used to evaluate the quality of reasoning in argumentation. In this approach, learning to argue is viewed as learning a variety of argument schemas (Chinn, 2006). For example, reasoners who employ arguments about sample size can be viewed as having rich underlying schemas that specify when the sample size argument can be applied, when it is inapplicable, why the sample size argument is valid, how the needed sample size varies according to relevant variables such as the variability of the population, and so on. Reasoning schema analyses can be used to chart the development of particular argument forms used by individuals and groups. This method provides a rich understanding of students' understanding of the content of reasoning.

A fifth type of measure that could be applied to argumentation but has not yet been extensively applied is an analysis of the overall *argumentative stance* taken in the argumentation. In some argumentation, the predominant stance is one of *persuasion*; participants are trying to persuade each other that their view is correct. Other argumentation seems to take a *problem solving* approach, where reasons are advanced not primarily to persuade (though persuasion may occur) but to solve a problem jointly. Other possible stances exist, as well. It seems reasonable that the stance taken may powerfully influence the cognitive and affective outcomes of argumentation.

Summary

Although none of these measures taken singly provides a full picture of the quality of students' argumentation, careful choice of two or three measures together can provide a much more complete picture of collaborative argumentation. Researchers could improve research on argumentation by employing a broader range of measures.

Representations for Analyzing Tool-mediated Collaborative Learning

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Introduction

Sociocultural theories 1) argue that learning is inherently social and situated and 2) emphasize the critical role of tools in mediating learning (Cole, 1996). This suggests a view of learning that is quite complex, There are a variety of approaches to examining collaborative learning discourse. Analyzing the complexity of such collaborations is often done using intricate multilevel coding schemes (e.g, Chinn & Anderson, 1998; Engle & Conant, 2002; Hmelo-Silver, 2003). Other researchers have used more qualitative approaches to studying collaboration, such as Roschelle's (1996) study of computer-mediated convergent collaborative conceptual change. The latter provides a detailed look at portions of a collaborative process, focusing on social and linguistic processes. Some of the former approaches blend reliable cognitive and social analyses over larger periods of time but lose the chronological detail and often, the relation between different kinds of utterances. Because we are interested in how the different aspects of discourse relate to each other, as well as to the tools being used in the collaborative learning process, a better understanding of how collaborations unfold and how tools are used is crucial. This requires going beyond the coding of individual speech acts. The use of Chronologically-ordered Representation for Tool-Related Activity (CORDTRA) is one way of achieving this understanding. This technique is a generalization of the CORDFU methodology developed by Luckin et al (2001). Luckin and colleagues used this approach to examine how alternative ways of structuring hypermedia affected collaborative discourse, allowing them to explore relations between the software's features and collaborative knowledge construction.

CORDTRA Diagrams

CORDTRA diagrams contain parallel timelines that allow a researcher to juxtapose a variety of codes to understand an activity system—for example, these might be discourse, gestural, or tool-related codes (see Figure 1 for an example from Hmelo-Silver et al., 2005). Initially, we used this technique to examine face-to-face collaboration in a problem-based learning (PBL) tutorial to understand how constructing a drawing mediated learning (Hmelo-Silver, 2003). The work was expanded to study online collaborative learning in the eSTEP system (Hmelo-Silver & Chernobilsky, 2004; Hmelo-Silver *et al.*, 2005). eSTEP is an integrated online PBL environment for preservice teachers (Derry, 2006), containing a learning sciences hypermedia, a library of videocases, and an online activity structure that gives students access to a suite of individual and collaborative tools. We hypothesize that student learning and transfer will be enhanced when they repetitively bring together the conceptual ideas of the learning sciences with perceptual ideas from the classroom video. To explore this, we contrasted two groups who had used eSTEP (Hmelo-Silver & Chernobilsky, 2004). The CORDTRA analysis demonstrated that the more effective group started with initial discussion and exploration of the hypermedia and looked at the video as needed throughout their work—offering new ideas as they explored the video and deepening them during independent research. The students collaboratively developed and refined their ideas using the hypermedia and video in cycles. The less effective group worked sequentially, using the video early in their process and the hypermedia later. They engaged in a lot of tool-related discussion until late in the activity and spent little time on their final group product. We have used this analysis to generate hypotheses about how these tools might effectively mediate collaborative learning. We have also used CORDTRA diagrams to study the development of one group over time as they eSTEP on three problems (Hmelo-Silver *et al.*, 2005). The CORDTRA diagrams allowed us to see how the activity patterns changed over time as students moved from parallel lurking to active participation.

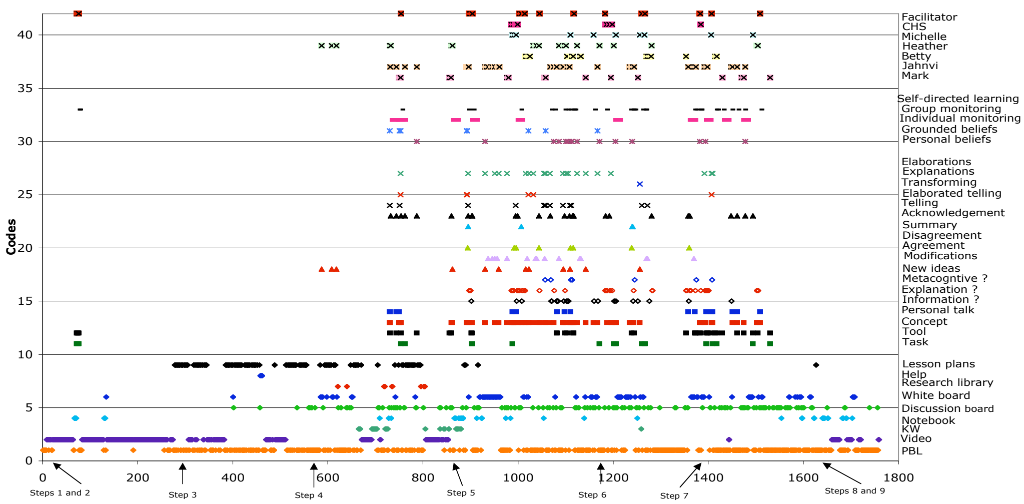

Figure 1. Example CORDTRA diagram

Understanding Patterns of Collaboration

We are expanding the use of CORDTRA as a means to examine patterns in many groups over time, determining how the nature of online discourse affects tool use and how the tools in turn affect the online discourse. CORDTRA analyses are an important addition to multilevel coding schemes, allowing researchers studying collaborative learning to go beyond coding and counting to seeing the larger patterns that emerge. This presentation will show examples of how CORDTRA diagrams can be used to illuminate tool-mediated collaborative learning.

A Perspective on Collaborative Learning informed by a Focus on Outcomes

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Introduction

What should we expect peers to learn from opportunities to collaborate with others? Various implementations and analyses of collaboration learning reflect significant differences in underlying theory, methods, and outcomes. Depending on the group process that occurs within a collaborative group, the actual collaborative process of different groups engaging in the same task may be explained by appealing to differing theoretical perspectives. Analyses of groups from the perspectives of these varied theoretical perspectives may allow for the identification of dimensions of interaction that are necessary to allow for explanations of effective groups.

In the study described here, students in three-person groups were asked to read a case about the classroom difficulties experienced by a new teacher. They were asked to identify her problems and to develop a plan to help her solve the problems. No strategy was imposed on student groups. They were to come to consensus on their plan. All participants were provided with the actual case but groups of participants were provided with access to varied ancillary information. The purpose of doing so was to increase the information sources available in the group.

Method

Participants took part in two sessions, separated by a one-week interval. Students signed up in triads. The first set of questions (# 1-5) were intended to have students rehearse knowledge of the specifics of the case. Question 6 was the central question: "What should Maggie do about the class behavior? Develop a plan for what she should do." Participants were directed to come up with a joint plan. They could either make a single record of the agreed-upon plan or they could record this agreed-upon plan separately. During the second session, which took place a week later, participants were asked to recall the jointly constructed plan for what Maggie should do about the classroom behavior. They were reminded that they were to recall the *group's plan* and not their own. A total of 76 groups (n=228) participated.

Results

Transcripts of the discussions that resulted in the initial plan allow for the identification of contributors to decisions made that subsequently were recorded as part of the group plan. The individual recall protocols from the second session allow for the analysis of whose ideas were recalled. These data allow an examination of how influence is accomplished in a group. The plan created by each group was used as the basis for the analysis. Each idea in the plan was listed. The transcript of the session related to the development of the plan was examined to identify who had contributed ideas that were eventually included in the plan agreed upon by members of the group. Each idea recorded on the plan was credited to the student who introduced the idea on the tape. In addition, if another student picked up on this idea in the discussion (e.g., supported the idea, elaborated upon it), that student was also credited. Each students' recall was rated for the number of ideas recalled, the number of ideas in the recall that were not part of the group's plan, the number of ideas that the student recalled and had been contributed by that student in the transcript, and the number of ideas that they recalled that were contributed by others. Analyses of these data suggest that individuals tend to retrieve the ideas they personally contributed to a plan and are influenced rather infrequently by others. This pattern of influence may be best described by information processing theory. Not all group's interactions and influences can be described in this way, however. Further analyses of groups that did not conform to this interpretation are currently being conducted.

Discussion

The method used to look at "joint cognition" has promise. The recorded plan for groups represented what the group members believed to be their consensus about how Maggie (the first year teacher) should proceed. However, recall of the joint plan was often poor and a great many additions were often added. Group cohesion can be detected in the shared recalls of group members.

In many ways, the characterization of what constitutes "joint cognition" here is very mechanistic. There is little attention paid (thus far) to the quality of the plan. The purpose here is mainly descriptive and answers the question: "Do people include other people's ideas in their recall?" This work is beginning to address within this limited context what is learned in groups.

Automatic coding of communication in collaboration protocols

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Introduction

Initially, analyses of computer-supported collaboration focused on surface level characteristics of the communication, such as the number of messages sent (Strijbos, Martens, Prins, & Jochems, 2006). However, over the last 15 years the analysis of communication protocols is being used more and more to study collaboration processes (Rourke & Anderson, 2004). The development of a systematic and valid method that can be used to analyze communication protocols can be difficult. Furthermore, the process of analyzing a great number of protocols can be time consuming. Therefore, in order to speed up the process of coding communication protocols, an automated coding system was developed. This paper aims to describe the automatic coding procedure. Furthermore, it focuses on reliability, validity and limitations concerning the developed procedure.

Method and Results

The coding system developed identifies 'dialogue acts,' that is, the communicative function of each utterance typed by students during online collaboration and communication. Five main communicative functions are distinguished: *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). A total of 29 different dialogue acts are specified. For instance, an *imperative action* (*ImpAct*) indicates a commanding utterance with regard to a specific action to be taken.

To automatically code a protocol and identify which dialogue acts are used during collaboration, the *Multiple Episode Protocol Analysis* (MEPA) computer program is used (Erkens, 2003). This program can be used for the analysis and coding of collaborative discussions. Additionally, the program offers facilities for automatic coding. A production rule system was created that automatically categorizes utterances into dialogue acts. A set of *if-then* rules uses pattern matching to look for typical words or phrases, in this case for discourse markers. Discourse markers are characteristic words signaling the communicative function of a phrase in conversation in natural language (Schiffrin, 1987). For example, *why* at the beginning of an utterance usually indicates an *open question (EliQstOpn)*. The developed production rule system consists of a rule system for automatic segmentation of utterances in single messages (300 rules) and a rule system for dialogue act coding (1250 rules). This way, MEPA is able to code a protocol consisting of 1,000 utterances in less than a second.

Although automatic coding can dramatically speed up the coding process, several methodological issues concerning reliability and validity need to be addressed. One concern is the reliability of the automatic coding procedure. A previous study showed that reliability of the automatic coding procedure was high: two independent coders established that over 90% of the utterances were coded correctly (Erkens, Jaspers, Prangsma, & Kanselaar, 2005).

Examinations of group differences can be used to establish validity of the automatic coding procedure (Rourke & Anderson, 2004). Since previous research has shown that men and women behave differently during collaboration (Leaper & Smith, 2004): women use more affiliative speech (e.g., praise and responsiveness), whereas men use more assertive speech (e.g., negative speech and directives), it would be useful to examine these if differences are replicated using the automatic coding procedure. Indeed, in our sample female students used more responsive dialogue acts, whereas male students used more imperative dialogue acts. This result is a first step in validating the automatic coding procedure. Another way to establish validity of the automatic coding procedure may be through experimental intervention (Rourke & Anderson, 2004). In order to stimulate student participation and argumentative knowledge construction, a new tool was added to an existing CSCL-environment. Indeed, as expected students with access to this tool used more argumentative dialogue acts, compared to students without access to this tool. Thus, the results described above indicate that the automatic coding procedure does not only speed up the coding process, but also seems to yield reliable and valid results.

Conclusion

Preliminary results indicate favorable results concerning the validity and reliability of the automatic coding procedure. Additionally, the results of the automatic coding procedure will be compared to results obtained with a manual coding procedure. This manual coding focused on the collaborative activities students perform during collaboration in a CSCL-environment (Janssen, Erkens, Kanselaar, & Jaspers, in press). Results concerning this comparison of 'dialogue acts' and 'collaboration acts' will also be presented. Although results of the automatic coding procedure do not provide insight into the structure of online discussions (see also Chinn, this symposium), the procedure can be a starting point for more complex, sequential analyses. These sequential analyses can subsequently be used to capture the structure and quality of online discussion (e.g., Erkens, Janssen, Jaspers, & Kanselaar, 2006). Taken together, such an approach may constitute a valuable tool for researchers interested in analyzing collaborative discussions

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