Comparing the Roles of Representations in Face to Face and Online Collaborations

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Abstract. The paper reports an empirical study comparing the role of discourse and knowledge representations in face to face versus distance collaborative learning. Findings indicate that the role of knowledge representations shifts from being used to summarize verbal reasoning to a place to propose ideas before they are discussed. Implications for the design of multirepresentational online learning systems are discussed.

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Introduction

Online collaborative learning intrinsically requires that learning be mediated by external representations. These representations may include discourse representations (e.g., the chat rooms and threaded discussion tools by which learners and teachers communicate in their native language (Herring, 1999), disciplinary representations (e.g., visualizations and designed artifacts (Ainsworth, et al., 1998), and knowledge representations (symbolic representations of one's theories and reasoning; e.g., Suthers, et al, 1997). Unlike the spoken discourse of proximal collaboration, the discourse in distance collaboration takes place in a software-supported representational medium. Given the total reliance on external representations in online collaborative learning, it is appropriate to ask how these representations should be designed to facilitate collaboration. Of particular interest is coordination between the different types of representations listed above (Hoadley & Enyedy, 1999; Turoff, et al., 1999).

Our prior work on external representations in face-to-face collaborative learning situations has shown that differences between representational notations can translate into differences in the focus of learners' discourse and collaborative activities (Suthers & Hundhausen, 2001, 2002). In this paper we report on our first extension of this work to a study of how alternate representations might influence collaboration in distance collaboration situations. The study reported in this paper compares Proximal (face to face) with Distal (synchronous collaboration via networked software) conditions. We considered two divergent hypotheses: (1) The influence of representations in the Distal condition will be weaker because of the lack of implicit "taken as shared" meaning that results from working together in front of a physically shared display, and because of the greater difficulty of utilizing the representations as a resource for conversation through deixis. (2) The influence of representations in the Distal study will be stronger because participants may rely more on them for their communication in the absence of face-to-face communication. Our results showed that the distribution of activity was quite different between the Proximal and Distal groups, and this distribution provides evidence of both predicted influences. We discuss broader implications for the nature of collaborative learning with knowledge representations.

Design

We compared performance of participants using a Graph representation face to face (Proximal) to a synchronous distance collaboration version of the Graph condition (Distal). Both groups were given the identical task of exploring an unsolved "challenge problem"—presented as a series of textual web pages—by recording data, hypotheses, and evidential relations as they encountered them. We recruited 20 students in self-selected, same-gender pairs, out of introductory biology, chemistry, physics, and computer science courses at the University of Hawai`i. Participants were all under 25 years of age and were native English speakers.

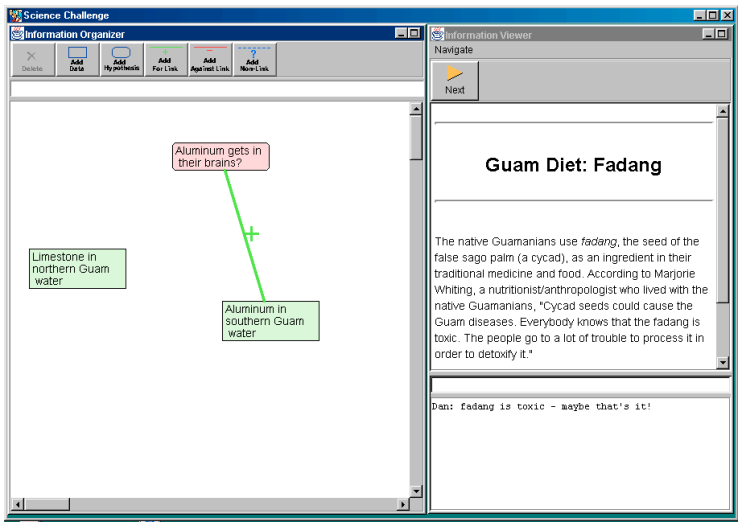

Figure 1. Collaboration Interface

Pairs of participants used one of two different versions of software for representing data, hypotheses, and evidential relations. The Distal version is show in Figure 1. Participants used the upper right hand window to move forwards through a sequence of 15 pages that presented information relating to the cause of a mysterious neurological disease on the island of Guam. The left-hand window contained a graphical tool for constructing representations of the data, hypotheses, and evidential relations participants gleaned from the information pages on the right. The graph tool is based on Belvedere (Suthers et al, 1997), and enables one to build a graph of nodes expressing data items and hypotheses, and links labeled "+," "-," or "?" representing evidential relations.

The software for the Distal condition provided a simple chat tool in an additional window in the lower right (Figure 1). Messages typed into a chat entry box were sent to both participants' shared chat displays once the message was completed and the "send" button pressed. Both versions of the software support deixis by causing the color of objects to change when one passes the cursor over them, enhancing the deictic value of the cursor and thus the ability to use the representation as a resource during conversation. The Distal version of the software replicated these color changes to the remote display.

Participants first worked on a warm-up problem (on mass extinctions), which was completely unrelated to the main problem, so that they could become acquainted with the software and the information-recording process. After 15 minutes, participants were instructed to stop work on the warm-up problem, and to move on to the main problem (on a neurological disease). Participants were given as much time as they needed to explore all 15 pages on the main problem in linear order (one could not go back to previous pages). Following the learning session, participants were given 20 minutes to individually complete a multiple-choice post-test, and 30 minutes to collaboratively write an essay that discussed their hypotheses and the evidence for and against them.

Results

Posttests showed no significant difference between Proximal and Distal groups, as expected due to the short treatment period. In this paper we focus on a categorical analysis of verbal and representational acts.

Analysis

Video/audiotape of the proximal sessions were transcribed by hand. The software generated transcripts of the distal sessions automatically. Transcripts were divided into "segments," each consisting of a verbal or typed utterance (multi-propositional utterances were divided into individual segments) or a change to the representation. See Suthers & Hundhausen (2001) for details of coding. Then we performed a content analysis of participants' learning processes by coding all segments in the 30 transcripts into mutually exclusive "topic" categories.

Distribution of Categories

There were many more segments in Proximal (4798) than in Distal (2898). The percentages of each category relative to the total count for each group are shown in Figure 2. The most striking differences in the percentages are in Domain Talk, Epistemological Classification and (to a lesser degree) Evidential Relation. The Proximal participants engaged in a greater percentage of Domain Talk. Distal participants engaged in a greater percentage of Epistemological Classification and Evidential Relation.

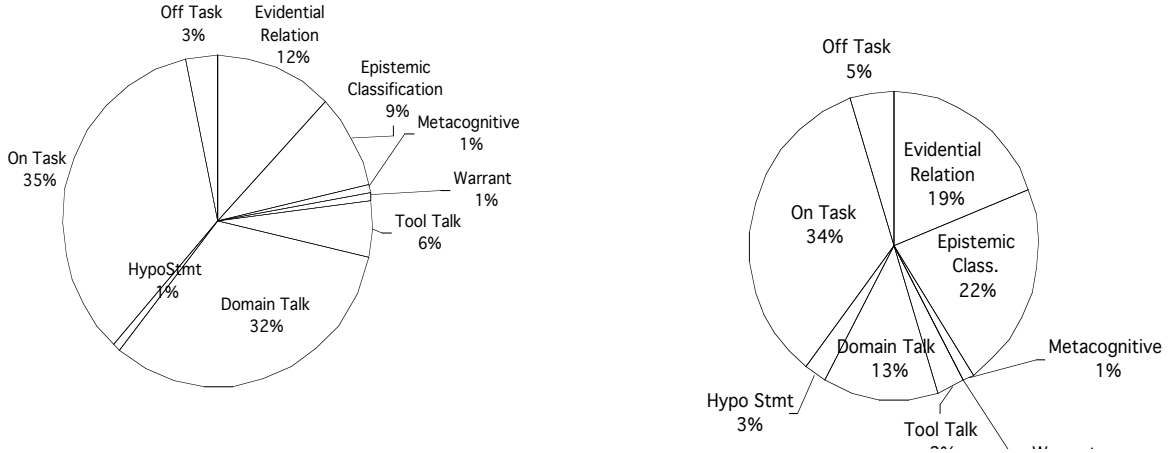

Figure 2. Percentages of each category compared

Table 1 shows Verbal and Representational breakdowns of the Evidential Relation and Epistemological Classification categories, which are those categories we focused on in the previous study. For the purposes of this study, "Verbal" means spoken in the Proximal condition and use of the Chat tool in the Distal condition; while "Representational" means use of the Graph tool in both conditions. The table shows both raw counts and percentages of On-Task, Non-Recited segments (therefore the percentages differ slightly from those in Figure 2, which are of the total number of segments). We performed statistical tests on percentages rather than raw counts to control for differences in verbosity between groups. We compared each Proximal/Distal pair of percentages shown in the table using a Kruskal-Wallis ANOVA provided by Analyze-It™.

Table 1. Breakdowns of Evidential and Epistemological Classification Acts

		Total Counts		*Percentage of On-Task, Non-Recited, and p levels*		
Code		**Proximal**	**Distal**	**Proximal**	**Distal**	**p**
On-Task, Non-Recited		4530	2724			
	Verbal	3646	1590			
	Representational	884	616			
Evidential Relations		569	561	12.56	20.15	
	Verbal	314	35	6.93	1.28	.0001
	Representational	255	514	5.63	18.87	.0002
Epistemological Classification		439	644	9.69	22.83	.0007
	Verbal	120	24	2.65	0.88	.005
	Representational	319	598	7.04	21.95	.0004
Domain Talk		1618	368	35.72	13.53	.0002
	Verbal	1311	367	28.94	13.50	.0005
	Representational	307	1	6.78	0.04	.0001
Hypothesis Statement		38	76	0.84	2.80	.0409
	Verbal	38	75	0.84	2.76	.0409
	Representational	0	1	0.00	0.04	.3173

Discussion

A split in emphasis between Verbal and Representational is seen across Proximal and Distal. Participants in the Distal study represented the Epistemological Classification and Evidential Relation categories over two times more than Proximal participants. However, Proximal participants verbally discussed Epistemological Classification nearly five times more than Distal participants, and Evidential Relation categories over nine times more than Distal participants.

A greater percentage of acts in the Distal condition were concerned with categories provided by the representations (Epistemological Classification and Evidential Relations). In the case of Evidential Relations, the counts were similar, so this reflects a difference in the denominator: perhaps the same amount of evidential thinking is taking place in context of less overall talk. However, a greater number of the Distal Evidential relation acts are classified as "Introduced," that is, as reintroduction of the topic of evidence rather than a continuation of an ongoing discussion of evidence. Given that many of these acts are representational, Distal participants may be using the Graph medium to propose evidential relations, resulting in less overall talk but many representational introductions of Evidential Relations. Thus, the representational medium becomes part of the conversational medium, a point we will return to.

Both numerically and in percentage, there were many more Epistemological Classifications in Distal. This result would also be consistent with the interpretation that new objects are being created in the Graph representation to propose ideas, as each object creation event is also coded as a classification event.

There was more Domain talk in the Proximal condition. Domain Talk made up nearly five times more of total Proximal utterances than Distal chat. Perhaps this difference is due to the extra work required to type in Chat; the concepts and more complex propositions of an unfamiliar domain being most subject to this resistance of the discourse medium. However, the Hypothesis Statement category, in which participants proposed hypotheses without classifying them as such, was observed twice as often in Distal discourse. More Distal discussion tends to occur after the last page, when participants are asked to come to a final conclusion. This discussion consists largely of hypothesis statements, which are by definition conclusions not classified or represented as hypotheses (e.g., "I think it's the water").

Although further analysis is needed to determine whether representations influenced discourse and learning more in one mode than the other, it is already apparent the timing and purpose of discourse related to representations differed considerably. For Proximal participants, collaboration and agreement tended to be forged before representations were made, so the representations may be seen as an external product of the discourse. For Distal participants, on the other hand, the Graph representation served multiple purposes. As in the Proximal condition, Graphs functioned as a stimulus to and product of discourse. Additionally, they were used as part of the discourse medium themselves. Participants often proposed new items or relations by creating them in the graph medium, whereupon chat focused on approval or disapproval. Also, participants used the graphical representation in place of the chat tool to send a message that was deleted. The Graph was also used in a manner peripheral to discourse, when a participant independently modified the graph amidst unrelated Chat discussion. Often, Distal discourse related to representations occurred at the end of the session after all representations had been made and participants were urged to come to a final conclusion, or immediately after each representation, with short, superficial comments such as "Looks good" or "Okay."

The referencing of knowledge representations was another issue affected by discourse mode. Coordination between discourse mode and diagrammatic media was easier for Proximal participants because they could non-verbally reference items for clarity. They simply pointed to an item on the screen or clicked their cursor when determining a relationship or discussing an issue. This ability to easily reference items and determine that they were both focusing on the same items may have allowed them to discuss more items and relationships. Distal participants, on the other hand, rarely referenced items that had been previously represented, except for those that had just been added. In that case, discourse often involved simple agreements with the change in statements like, "Looks good." When they did reference older items, they tended to use words contained in the item rather than referring to the location of items, i.e., "The water one" rather than "The one on the top."

Conclusions

We began this study hoping to learn more about the differences between proximal and online collaboration before we launch into full-scale studies of online collaboration. Our future work will focus primarily on asynchronous rather than synchronous online collaboration. This study has helped bridge to that work.

Two hypotheses were considered: (1) that visual knowledge representations would play less of a role in guiding discourse because without co-presence they do not as easily function to convey "taken as shared" information or to support deixis; (2) that visual knowledge representations would play a greater role in supporting discourse because participants would make use of them to make up for the reduced bandwidth of the verbal modes of interaction. Paradoxically, both of these seem to be supported by the study. The first hypothesis is difficult to address without a *comparative* study involving Matrix and Text representations (as we did in the Proximal study), to see whether the pattern of results changed. However, we have evidence for this hypothesis in the form of observed disconnects between the activity in the workspace and the verbal activity in the chat. Many uses of the knowledge representations as such are not as tightly coupled to verbal discourse as in the proximal case, so we would expect that their influence on verbal discourse would be weaker. We feel we have good evidence for the second hypothesis: the knowledge representations were used for transient negotiation normally undertaken verbally in the proximal case, such as proposing new hypotheses or relations.

Perhaps the major conclusion to be drawn from this study for the design of software for online learning is that close attention must be paid to the coordination (both in the design and in use) between multiple representations, if multiple representations are used. If users are able to modify more than one type of representation, the discourse process will not be confined to the medium provided for discourse: it will be distributed across all mutable representations. Therefore the software should support fluid crosstalk between all representations by making the relationships between different representations and between acts on those representations clear.

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