The Organization of Collaborative Math Problem Solving Activities across Dual Interaction Spaces

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Abstract. In this paper we focus on the organization of activities that produce shared graphical representations on the whiteboard of a CSCL system with dual interaction spaces called VMT Chat, and the ways these representations are used in conjunction with chat postings as semiotic resources by interactants as they jointly make sense of and build upon each other's mathematical statements.

Keywords: Dual interaction spaces, interaction analysis, shared representations

Introduction

Dual Interaction Spaces (DIS), which typically bring together two synchronous communication technologies such as a text-chat and a shared workspace, have been widely used to support collaborative learning activities online (Dillenbourg & Traum, 2006; Mühlpfordt & Wessner, 2005; Jermann, 2002; Soller & Lesgold, 2003). The way such systems are designed as a combination of two technologically independent communication mediums bring significant interactional consequences for the users (Stahl et al., 2006; Mühlpfordt & Stahl, 2007). Despite the popular use of DIS in CSCL applications, there are only a few studies about how small groups organize their interaction in these environments. Existing approaches include: (a) modeling actions performed across both mediums and the problem space to seek relational patterns among ontological entities (Avouris et al., 2003); (b) employing content analytic methods to study the correlation between planning moves and the success of manipulations performed in the shared workspace (Jermann & Dillenbourg, 2005) and (c) the relationship between grounding and problem solving in DIS environments (Dillenbourg & Traum, 2006). In particular, by framing their analysis along the lines of Clark and Brennan's (1991) theory of grounding, Dillenbourg & Traum (2006) identify two kinds of uses of the dual spaces to facilitate grounding at various temporal levels during problem solving sessions, namely the napkin and mockup models. Moreover, since participants organized key factual information relevant to the problem at hand on the shared whiteboard during their experiments, the authors attributed a *shared external memory* status to this space and claimed that it facilitated grounding by offering a more persistent medium for *storing* agreed upon facts.

The notion of common ground as an abstract placeholder for registered cumulative facts or pre-established meanings has been critiqued in the CSCL literature for treating meaning as a fixed/denotative entity transcendental to the meaning-making activities of inquirers (Koschmann, 2002, p20; Stahl, 2006a, p354). As an alternative to previously proposed approaches that involve modeling of actions and correct solution paths, or treating shared understanding as alignment of pre-existing individual opinions, in Stahl et al (2006) we have begun to develop an interactional perspective to study the intersubjective meaning making activities of small groups mediated by DIS environments. In this paper we build on our previous work on referencing math objects in chat by focusing on the sequence of actions in which participants co-construct and make use of *semiotic resources* (Goodwin, 2000) distributed across dual interaction spaces to sustain their collaborative problem solving work on open ended math tasks (Stahl, 2006b). We also compare the affordances of both mediums based on the ways their contents were used as semiotic resources by the interactants.

Analysis

The data excerpts we used in this paper are selected from the time-stamped logs of collaborative problem-solving sessions sponsored by the Virtual Math Teams (VMT) project. VMT is an NSF funded research program through which researchers at the Math Forum and Drexel University investigate innovative uses of online collaborative environments to support effective K-12 mathematics learning. During these sessions participants interacted through a tool called VMT Chat, which provides a shared drawing area, a text-chat window, and a tool for explicit referencing that allow users to visually connect their chat postings to prior postings and/or to objects on the board (Mühlpfordt & Wessner, 2005). In the following subsections we present a summary of our overall findings[1] about the ways both spaces were used as semiotic resources by small groups of students as they collaboratively co-constructed and made sense of mathematical arguments in the VMT Chat environment.

Availability of the Production Process

Whiteboard and chat contributions differ in terms of the availability of their production process. In the chat area, participants can only see who is currently typing, but not what is being typed until the author decides to send his/her message. A similar situation applies to atomic white board actions such as drawing a line or a rectangle. However, the construction of most shared diagrams includes multiple atomic steps, and hence the sequence of actions that produce these diagrams is available for other members' inspection. Hence, the whiteboard affords an animated evolution of the shared space, which makes the visual reasoning process manifested in drawing actions explicit due to its instructionally informative nature.

Mutability of Chat & Whiteboard Contents

The two interaction spaces also differ in term of the mutability of their contents. Once a chat posting is contributed, it cannot be changed or edited. Moreover the sequential position of a posting cannot be altered later on. If the content or the sequential placement of a chat posting turns out to be interactionally problematic, then a new posting needs to be composed to repair that (Garcia & Jacobs, 1998). On the other hand, the object-oriented design of the whiteboard allows users to re-organize its content by adding new objects and by moving, annotating, erasing, reproducing existing ones.

Chat vs. Whiteboard Contributions as Referential Resources

Chat postings and objects posted on the whiteboard differ in terms of the way they are used as referential resources by the participants as well. The content of the white board is persistently available for reference and manipulation, whereas the chat content is visually available for reference for a relatively shorter period of time. This is due to the linear growth of chat content which replaces previous messages with the most recent contributions at the bottom of the chat window. Although one can make explicit references to older postings by using the scroll-bar feature, the limited size of the chat window affords a referential locality between postings that are visually proximal to each other. This visual locality qualifies the whiteboard as the more persistent medium as a semiotic resource, although both mediums technically offer a persistent record of their contents.

Past and Future Relevancies Implied by Shared Drawings

As part of an ethnomethodological study of cognitive scientists' whiteboard use during design meetings in a face-to-face setting, Suchman observed, "…while the whiteboard comprises an unfolding setting for the work at hand, the items on the board also index an horizon of past and future activities" (1990, p317). VMT Chat's whiteboard serves a very similar interactional role, in the sense that what gets done now informs the relevant actions to be performed and messages to be posted subsequently, and what was done previously can be reproduced or reused depending on the circumstances of the ongoing activity. Moreover, the drawings on the board have a figurative role in addition to their concrete appearance as illustrations of specific cases. The particular cases captured by concrete, tangible marks on the board are often used as a resource to investigate and talk about general properties of the mathematical objects indexed by them.

Discussion

In this study we attempted to highlight how small groups use shared representations and chat messages together as semiotic resources in mutually elaborating ways during their collaborative math problem solving activities in the VMT Chat environment. The complex relationships between the actions that took place across both interaction spaces made it difficult for us to describe what we have observed by using either the mockup or napkin models offered by Dillenbourg & Traum (2006). Instead, we have observed that in the context of an open-ended math task groups exhibit each type of organization during

[1] Due to space limitations we could not include excerpts that illustrate the findings reported in this manuscript

brief episodes in the course of their entire session depending on the contingencies of their ongoing problem solving work. For instance, during long episodes of drawing actions where a model of some aspect of the shared task is being co-constructed on the whiteboard, the chat area often serves as an auxiliary medium to coordinate the drawing actions (i.e. mockup model); whereas when a strategy to address the shared task is being discussed in chat, the whiteboard is mainly used to quickly illustrate the ideas stated in text (i.e. napkin model). Moreover, we have observed that the whiteboard not only serves as a kind of shared external memory space to keep a note of the agreed upon facts, but also provides semiotic resources that participants rely upon as they make sense of the unfolding sequence of actions. The availability of the contributions posted on both spaces constitute an evolving historical context in which participants decide upon relevant steps to pursue next and make sense of new contributions in relation to the semiotic resources persistently available on the shared visual field.

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