Juxtaposing Practice: Uptake as Modal Transposition

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Abstract: The analysis discussed in this paper draws attention to the interactional and inscriptional practices observed in a science laboratory setting that utilizes Group Scribbles. The critical finding is the identification of a pivotal sequence of interaction occurring in the later half of the activity in which one member of the group proposes an innovation for illuminating two light bulbs in a single circuit. The proposal and its subsequent endorsement by the other members are contingent on an immediately prior interaction in which the group appropriates another group's circuit diagram. Together, this pair of adjacent sequential structures exposes multiple instances of uptake between participants. These uptake relations are realized through an ensemble of contingencies consisting of persistent diagrams, tabletop materials, and a locally situated interactional practice. Our analysis shows how the participants' actions transform the setting and how these transformations are consequential for how the group proceeds in the learning activity.

Introduction

Laboratory science classrooms provide rich sources of data for understanding collaborative learning in small group settings. Laboratory activities place learners in a position to experience scientific phenomena and engage in practices of inquiry. In many cases these activities are organized in participant configurations ranging from pairs to groups of three or four learners situated at the "lab bench". Such activities typically consist of a teacher's instructions on procedure and access to instruments and materials needed for the experiment. In the present work we analyzed the recorded interaction of four fifth graders in a Singapore primary school as they collaborated during a thirty-minute lab activity about battery powered electrical circuits. The group is one of ten other groups situated around tables in the classroom. Each table has four tablet personal computers, one for each student, as well as a collection of batteries, small light bulbs, and wires for building circuits. The students also use the Group Scribbles (GS) software installed on each tablet computer to draw diagrams of the circuits they are experimenting with (Roschelle et al., 2007). Using the GS tools, students can share their individual diagrams with their group by dragging them to a public area of the screen. Likewise, drawings in the public area of a group's screen can be shared with others in the classroom allowing the distribution of artifacts between groups. The inclusion of the Group Scribbles technology provides us an opportunity to assess important connections between meaning making and the appropriation of technology resources.

This paper reports on our investigation of the interaction practices of the learners as they coordinate their actions in a multimodal setting as part of an authentic laboratory science activity. Within this relatively short time frame we are able to piece together a detailed example of how the group deploys practices for handling their work at the "lab bench" as well as the ways in which persistent inscriptional artifacts permeate the group's setting. Our analysis focuses on a three-minute portion of the video record of the group's work in which they appropriate another group's circuit diagram and subsequently develop an alternative solution. By way of this analysis we also demonstrate an application of the use of uptake as an analytic approach for doing CSCL research in multimodal settings (Suthers, Dwyer, Medina, & Vatrapu, 2010). In the following section we ground our analytic approach and argue that it is a valuable approach for evaluating interactive phenomena of the type we are investigating in this paper. We then move on to our analysis and findings.

Background

Investigating practices within a particular setting is a matter of careful consideration of the connection between the sequential organization of participants' actions and the semiotic, material, and embodied aspects of that setting. Situated interaction has a mutual elaborating relationship with the environment (Suchman, 1987). The environment offers an array of external resources for action-relevant appropriation. Simultaneously, situated action modulates, redefines, or otherwise reconfigures the resources within the environment, thereby enabling and constraining subsequent acts. This dynamic ebb and flow of appropriation and modulation is sequentially organized (Garfinkel, 1994; Goodwin & Heritage, 1990). With respect to multimodal and embodied interaction Charles Goodwin writes,

> The issues posed for the analysis of action in such a setting involve not simply the resources provided by different semiotic systems as self-contained wholes, but also the interactive practices required to juxtapose them so that they mutually elaborate each other in a way

> relevant to the accomplishment of the actions that make up the setting. (Goodwin, 2003, p. 237)

The study of multimodal interaction requires an understanding of both the properties of these semiotic systems *and* how those systems are coordinated and appropriated in joint activity. This suggests two overlapping planes of study: recognizing the external properties of the setting in one and meaning making practices in the other.

Investigating interaction that takes place in a multimodal setting entails careful consideration of how participants' actions in the environment are made relevant for emergent, sequentially organized, and shared structures of joint activity (Sacks, Schegloff, & Jefferson, 1974). Sequential analysis techniques based on ethnomethodology and conversation analysis (EMCA) demonstrate, in a detailed manner, the contingent nature of human interaction (Çakır, Zemel, & Stahl, 2009). These techniques expose how the resources available in the setting of interaction are integrated in the very structure of communication that emerges in the activity. Taking the turn-by-turn pattern of interaction in any social activity as an analytic starting point has yielded valuable insights into the in-situ emergence of meaning making practices (Koschmann et al., 2005). Although conversation analysis was originally proposed to handle speech exchanges, numerous scholars have taken an EMCA approach, in principle, as an inroad to understanding interaction mediated by more semiotic rich settings such as online environments, scientific field work, and classrooms (Medina & Suthers, 2013; Goodwin, 1995; Roth, 2001).

The distribution of interaction across a setting has led many researchers to see the visual spatial field as a categorical entity in sequential analysis. Streeck and Kallmeyer's (2001) analysis of a rather mundane two-party business negotiation offers an example that suggests that graphic inscriptions can be taken as a form of interaction that offers a different set of opportunities for meaning making beyond conversation. The act of inscribing during interaction carries with it not only that which is being represented, its instrumental purpose, but perhaps less obviously its discursive function. Inscriptions, once recorded in a medium (paper, whiteboard, computer screen, etc.), offer structures for making arguments, substantiating claims, and indexing a range of situation relevant and epistemologically consistent communicative action. The sequential organization of inscriptional activity carries structural (e.g. rhetorical, canonical, or discursive) information that embodies taken as shared conceptions, concerns, and meanings that are relevant to the situation at hand. Inscriptional action draws upon an extended vocabulary from the visual field. They can embody forms of action such as a line intimating gesture (e.g. a line drawn around a figure may be a deictic reference to an aspect of the figure of concern in the interaction). Gesture is highly coupled with talk; however, inscriptions and instrumental acts occur independently of talk yet articulate it. This has not been studied at length especially in regard to how inscriptional action is sequentially organized. Streeck and Kallmeyer (2001) write,

> Actions that can occur independently of talk, however - instrumental acts, inscriptions, and so on - have so far only rarely been studied for their possible participation in the construction of 'projectable' turns-at-talk. (Streeck and Kallmeyer, 2001, p. 469)

Inscriptions that once served as a field of calculation and measurement can be reinstated in rhetorical contexts to persuade, compare, and express ideas. Further, persistent inscriptions enable variable, situation relevant courses of action over time and setting (Latour, 1990).

Still, while arguing for analytic accountability of inscriptions and non-verbal modalities in the setting, Streeck and Kallmeyer warn against oversimplifying or fragmenting components of interaction across modal and material properties. Rather, they suggest that ongoing interaction draws upon multiple vocabularies in the making of meaning. Thibault (2011) goes further in advising against the rush to discover and extrapolate upon regularities of symbolic systems. The prudent starting place is the distributional character of communication across the senses, materiality, and symbols.

The analytic approach considered in this paper takes interaction as fundamentally multimodal and sequentially organized. Underlying theoretical assumptions are based on the notion that participants build their interaction through the moment-by-moment or otherwise sequential exchange of actions. These actions are potentially distributed across all available aspects of the setting. As Goodwin's quote makes clear, the study of interaction practices exposes the relationship between the setting and the joint activity of the participants.

Through analysis of practice we gain a rich understanding of the distributional character of action and its implications for computer supported collaborative learning and teaching in classrooms, online settings, and instances of both. Sequential multimodal interaction analysis can be used to uncover the relationship between the properties of the environment and the interactional practices that make those properties relevant and consequential for joint meaning making. More specifically, analysis of interactional practices is useful for understanding how inscriptional devices (verbal and nonverbal) are integrated in joint meaning making structures.

Uptake: A Relational Unit of Interaction

Making sense of the sequential structure of multimodal interaction presents a degree of complexity for analysis where participants' actions may be distributed across a diverse range of media. A useful strategy to begin with

might be the recognition of how any participant actions are evidenced to be relevant and consequential for the activity. How and where are actions *positioned* in the sequential unfolding of the activity and how and through what means do those actions relate to prior actions? The notion of uptake has been proposed as a useful concept for investigating precisely these questions.

Suthers, Dwyer, Medina, & Vatrapu, (2010) describe uptake as a relational construct that identifies a participant action as appropriating aspects of a prior or ongoing setting as relevant for ongoing interaction. This definition is deliberately abstract, enabling it to be purposed in a wide range of interactional settings. It is also intended to support a diverse range of theoretic and methodological approaches. Uptake provides an interpretive heuristic rather than a specific method of analysis (the authors describe it as a proto-analytic). The potential gain by interpreting interaction as uptake is that uptake does not privilege one particular communicative modality or granularity over another. A warranted interpretation of uptake only specifies that one human action is appropriating aspects of a prior or ongoing element of the setting while also transforming that setting. The value of uptake for the analysis of multimodal interaction is its provision for a more flexible consideration of sociological and environmental contingencies.

Group Scribbles Analysis

In the present work we analyzed the recorded interaction of four fifth graders in a Singapore primary school as they collaborated during a thirty-minute lab activity about battery powered electrical circuits (Chen, Looi, & Tan, 2010). The group is one of ten other groups in the classroom. Each group of four is gathered around a table. Each table has four tablet personal computers, one for each student, as well as a collection of batteries, small light bulbs, and wires for building circuits. In addition to these tabletop materials students also use the Group Scribbles (GS) software installed on each tablet computer to draw diagrams of the circuits they are experimenting with (Roschelle et al., 2007). Using the GS tools, students can share their individual diagrams with their group by dragging them to a public area of their respective screens. Likewise, drawings in the public area of a group's screen can be shared with others in the classroom allowing the distribution of GS artifacts (or drawings) between groups.

The students are instructed to begin the activity by drawing circuit diagrams using the Group Scribbles software. After these initial diagrams are complete they are instructed to evaluate their diagrams using the tabletop materials consisting of batteries, wires, and bulbs. Subsequently, over the course of the activity the students are reminded to record their exploration of circuits by diagramming different arrangements of the circuits they tested along the way.

The analysis presented in the following sections takes as a topic the multimodal interactional mechanisms demonstrated by the participants in the laboratory activity described above. The data consists of five synchronized video records of the entire thirty-minute activity. Four of the records were taken from screen capture videos of each of the four participants' tablet computer screens. The fifth video source was drawn from a camera situated adjacent to the participants' table. It captured a wide-angle view of the group's work including what they constructed on the table. The videos were imported and synchronized using the Tatiana software tool (Dyke, Lund, & Girardot, 2009). Tatiana allows simultaneous playback of all video sources. As the videos are viewed, transcriptions and analytic annotations are entered and stored in sync with the video timeline. Tatiana was useful for monitoring simultaneous events in detail. For example, at times we were able observe the drawing actions of a student by focusing on that student's screen video during the event sequence of interest. We could alternatively shift to the group video record to track how those actions related to the interaction of the group. In general, we conducted our video analysis using sequential microanalysis techniques similar in purpose to Jordan and Henderson (1995) although uptake is appropriated here because it offers a general heuristic at a suitable granularity for describing the empirical evidence. This is not to suggest that uptake is only a macro level construct. It can be utilized at any descriptive level appropriate for the analytic evidence on which it is grounded. In the present analysis, uptake is used to explicate the critical relations between participant actions that are distributed across time, media, participants, and material (classroom) artifacts.

The Group Scribbles classroom is organized like many similar learning environments that are computer supported, networked, and embodied in classroom situations. In these contexts interaction is distributed across modalities (verbal, nonverbal, textual, and visual-spatial). Three aspects of the activity were identified at the onset of the analysis. First, the students constructed a series of persistent inscriptions in the Group Scribbles environment. The production of these inscriptions, and their availability throughout the activity, suggested that inscriptions might have a role to play in ongoing group interactions. Second, the centrally located tabletop materials provided a visual spatial modality with respect to the spatial arrangement and placement of the various circuit parts such as batteries, wires, and bulbs. Third, the activity of the group is patterned. That is, the students' work occurs in a series of sequences each oriented to a unique problem or concern in the activity. The interrelation of these phenomena formed the basis for the following analytic questions.

1. How are Group Scribbles inscriptions appropriated and/or coordinated in joint action?

2. How are the elements of the (classroom) environment modulated by the situated actions of the participants and what are the consequences of this for their meaning making practice?

Observations

During the thirty-minute activity the students work through five different electricity circuit configurations, which we refer to as episodes (of interaction). For this paper we focus on the last two episodes (4 and 5) in which the group members develop an innovation for lighting two bulbs with one circuit. In the ensuing descriptions each student is referred to by his or her pseudonym, (Bruno, Serena, Agnes, and Joel). We begin with episode four.

Episode 4: Two-Battery-One-Bulb in Vertical Series

Using Group Scribbles Serena accesses another groups' diagram. She locates a diagram that has two batteries stacked upright one above the other with the light bulb contact directly on the positive end of the top battery. Two wires are arranged from the bottom of the lower battery up to the bulb shielding (see Figure 1a). Serena shares this diagram with the others by swiveling her screen around so that it faces Bruno and Joel. All four students orient to the diagram being referenced by Serena and agree to test its arrangement. The subsequent experimentation moves through two phases. In the first, Bruno and Joel have made an interpretation of the stacked diagram by proceeding to use a wire to complete the circuit connection between the bulb and the positive post of the battery. Serena publicly notes this inconsistency with respect to the diagram posted by group "SF_2". A subtle departure in the stacked diagram from the other diagrams the group has been working with is that the bulb appears to make direct contact with the positive battery post, bypassing the need for a wire (see Figure 1b). Serena points this out and grasps the bulb and places it directly on the positive battery post. The group then proceeds to successfully construct a working circuit using the stacked arrangement (diagrammed in Figure 2). The subtle yet critical diagrammatic placement of the bulb and its successful implementation appears to set up the group's immediate next experiment with two bulbs.

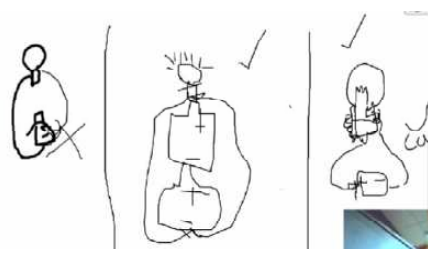

Figure 1a. Group SF_2's diagrams.

Figure 1b. Bulb contact (highlighted by the authors).

Figure 2. Agnes draws configuration.

Episode 5: Two-Battery-Two-Bulb in Vertical Series

The last experiment has the group attempting to light two bulbs. They are building on the "stacked" arrangement of the circuit they successfully tested in the immediately prior experiment (episode four). Joel initiates this experiment by spontaneously picking up two bulbs and placing them both directly on the positive post of the top battery. Joel performs this act while Bruno remains holding the batteries in the position they were in during the prior experiment. At this moment there is no direct evidence from the video record that the bulbs are actually lit. At the very least Joel's act is presenting an idea to the group. He appears to position the bulbs, then looks up to the group as if requesting their noticing (this moment is captured in the frame presented in Figure 3 inset 3 below). The group takes notice and excitedly proceeds to successfully construct the circuit with two bulbs.

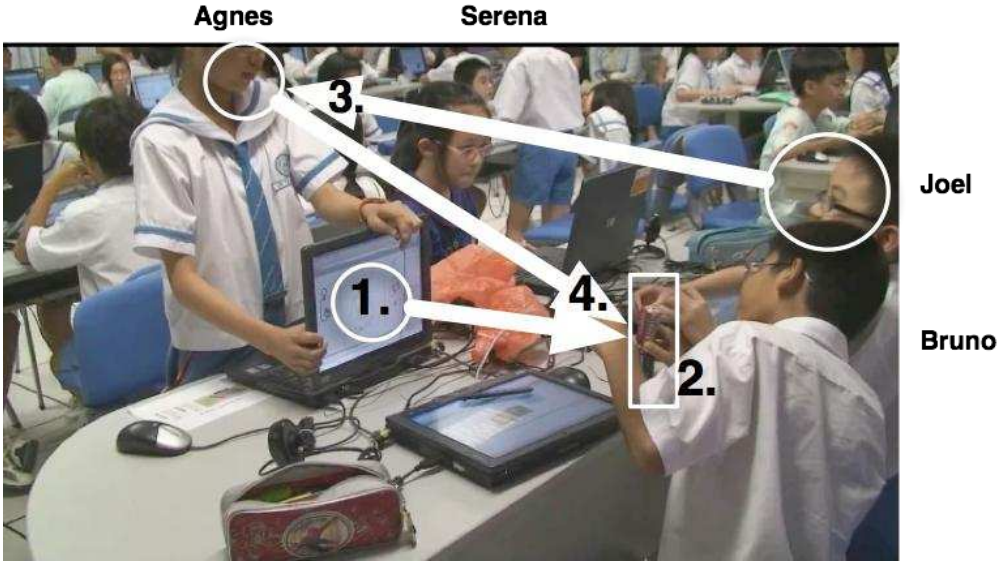

Figure 3. Proposing an innovation.

As noted above the group's approach does not require a wire for the positive contact (i.e. the bulb is placed directly on the positive post of the top battery). This innovation opens up the possibility of adding a second bulb to the positive post of the top battery. It is this opportunity that Joel seizes and demonstrates and that the others recognize. Subsequently, their competence at constructing a working circuit is evidenced in the efficiency at which they move from Joel's initial idea to a working two-bulb circuit.

Discussion

The sequence of interaction in episodes 4 and 5 described above demonstrate the learners' opportunistic appropriation of various elements of the setting to conduct their laboratory activity. Our analysis below reveals how the learners juxtapose their practices against the material and semiotic elements of the setting in order to coordinate their actions with the tabletop objects and the inscription displayed in the Group Scribbles screen. In the following we identify learners' uptakes to highlight critical aspects of the learners' coordination with the setting and to expose what we view as important implications for CSCL research and the design of media-rich technologies.

How Inscriptions Permeate Interactional Context: Representational Competence

In episode four, the group members have integrated another group's diagram into their interaction. The diagram is displayed on Agnes' screen and is directed towards the center of the table. It depicts a vertical arrangement of a circuit in which the bulb makes direct contact with the battery post (no wire is needed for that portion of the circuit), which the group had not previously considered. As Bruno and Joel work at reconstructing the diagram using the tabletop components, Serena notes that they have misinterpreted the diagram. She observes and demonstrates to the others a novel detail in the placement of the bulb with respect to the top battery (see Figure 1b). The group subsequently modifies their circuit to maintain consistency with the diagram.

Here we can observe a series of uptake relations. Bruno and Joel's reconstruction (using the tabletop materials) of the diagram is the first in the series. This uptake affirms the proposed relevance of the diagram to the group's ongoing physical experiment. Next, Serena takes up the result of this reconstruction when she observes how their arrangement is inconsistent with the diagram. Subsequently, Bruno and Joel rearrange the tabletop materials accordingly as they take up Serena's point. By definition, there are multiple uptake relations in which a participant action takes up aspects of the setting as relevant for the situation at hand and by so doing transforms the setting (Suthers et al., 2010). Bruno and Joel's uptake of both the diagram and the prior availability of the circuit materials result in a transformation of the experimental apparatus. In turn, Serena takes up this transformation and invokes the diagram that remains directed at the group (Figure 3, inset 1). Bruno and Joel take up Serena's indexical act by adjusting the experimental apparatus, once again relying on the previous setup. Figure 4 (uptake relations u1 through u6) summarizes the pattern of uptake discussed here. From an interactional exchange perspective, experiment four might appear rather straightforward and mundane. Interpreted as uptake, however, the brief exchange sheds a different light on the significance of interactions with

respect to how the participants are cooperatively and opportunistically appropriating a range of resources in the setting well beyond verbalization. Uptake relations show how a sequence of actions produces relationships between inscriptions and established practices for handling tabletop materials. Further, the very notion that Bruno and Joel can be referred to as jointly performing an action is a notable example of how tightly coordinated the participants' actions are with their laboratory practice for maintaining the experimental apparatus.

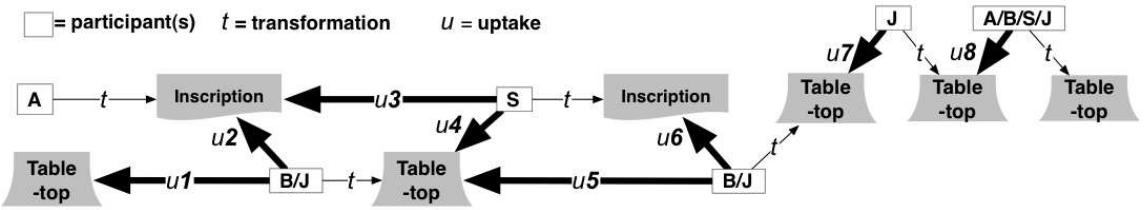

Figure 4. Uptake relations in episodes 4 and 5.

Episode four demonstrates a level of representational competence with respect to the group's ability to correlate the phenomena (electrical circuits), with its associated diagrammatic inscription (Kozma, 2003). In this group's work, there is a clear, non-abstract, relation between diagram and phenomena (bulbs look like bulbs in the diagram). The critical point, however, is that it is the group's orientation to Serena's indexical act that reveals that the others clearly understand the misinterpretation and immediately rectify the relations between diagram and phenomena. The diagram is appropriated for representation and as a resource for negotiated meanings.

Making a Proposal: Coordinating Actions

A second critical moment comes immediately after the group has completed episode four. At this moment (Figure 3) Joel makes his proposal for lighting two bulbs by building on the circuit configuration constructed in episode four. There are a number of points to note here. (1) The prior arrangement of circuit materials, originally taken up via a diagram displayed in the Group Scribbles software, remains intact on the table. Further, Bruno's hand remains on the batteries to keep them in the stacked position. These are physical contingencies for the formulation of ideas. The arrangement of batteries, wires, and bulbs require bodily coordination to be distributed across individuals and this is taken up by Joel to establish his proposal. (2) Joel places the two bulbs on the post and looks up towards Agnes as if to request a response. Agnes and Bruno take up Joel's act as demonstrating a new arrangement (two bulbs). After some excitement Serena, who has directed her attention at Bruno's and Joel's attempt to implement the proposal, reaches over the table to position the necessary wire to complete the circuit. In this instance, Serena is taking up the now established practice that requires coordinated arrangement and manipulation of the tabletop components to maintain the experimental apparatus. This practice became necessary over the course of the entire activity and is demonstrated once again here.

The proposed innovation offered by Joel and the subsequent uptake and implementation performed by the group demonstrates the coordination of multiple aspects of the setting. The proposal is initiated when the group reconstructs a circuit diagram depicted on Agnes' computer screen, which she has faced towards the group (Figure 3, inset 1; and described above). Joel's proposal and its recognition by the group members is achieved by a configuration of an indexical field consisting of the batteries held in place by Bruno along with Joel's placement of two bulbs (Figure 3, inset 2). Here, Joel is taking up a prior tabletop configuration and transforming it into another (Figure 4, u7). This is followed by his upward gaze towards the shared space above the table (Figure 3, inset 3), and Agnes' uptake of the gaze and position of the two batteries as communicating an idea (Figure 3, inset 4). Bruno's endorsement may be implicit as he maintains the physical apparatus to sustain Joel's communicative action. The group members are configuring the environment through multiple surfaces to mediate their meaning making. In this case the members of the group build on their prior locally available interactional practices for constructing experiments with electrical circuit materials. Evidence for this association is the placement of Bruno's right hand, (Figure 3), as Joel enacts his proposal for two bulbs. The configuration of body parts and orientation of the learners with respect to the table is entwined with the group's interactional context. The learners effectively take up the idea represented in the diagram by leveraging prior arrangements of bodies and hands. This arrangement is established over the course of the entire thirty-minute activity and constitutes important part of the group's interactional practice in an ongoing and changing semiotic context (Goodwin, 2007). This practice includes constructing and managing the experimental apparatus and attending to the relevant parameters of the problem. In this case, the learners have demonstrated evidence of

competence at both while also invoking the practice to make a discovery (Amerine & Bilmes, 1988; Koschmann & Zemel, 2009; Roth, McRobbie, Lucas, & Boutonné, 1997).

Confluence of Uptake

The final observation we wish to make rests on the notion of mutability. At the onset of experiment four, the group has been shown a diagram constructed by another group in the classroom. This diagram (Figure 1a) is an immutable mobile (Latour, 1990). Bruno and Joel's uptake of the diagram is to reconstruct its features using the tabletop materials. As detailed above, the next series of actions project through episodes four and five. Here we see demonstrated the transposition between modes such that the immutable object displayed on the screen is made mutable through its reconstitution in the tabletop materials. Realization of the affordance of mutability establishes the necessary relationship between the actors and the setting making it procedurally consequential (Schegloff, 1991). In other words, the uptake of the diagram transforms the setting by projecting the next set of relevant actions. These actions are to build a complete circuit, which requires the group to coordinate what they know about circuits and how to actually achieve the necessary arrangement of materials. This observation suggests that uptake relations that take the form of modal transposition (Peeters, 2010) may dramatically contribute to interactional practice because it invokes coordination with and the instantiation of the relevant aspects of the problem (Koschmann, LeBaron, Goodwin, & Feltovich, 2006). Competencies for reformulating ideas and concepts across modes has been used to assess levels of conceptual coherency in laboratory science activity settings similar to the one discussed in this paper (Lund & Bécu-Robinault, 2010, 2012). This is especially relevant for analysis of interaction at the lab bench where multiple resources are assembled and invoked by learners as they move through their inquiry. This view parallels Kozma's (2003) assessment of representational competence. In the case of our participants the placement of the bulb in episode 4 becomes a problem raised by Serena but only made salient after Bruno and Joel transposed the circuit from diagram to the tabletop.

Conclusions

The directive given to the participants was to use diagrams to reason about and explore the concept of electricity flow. This analysis showed how diagrams shared as classroom artifacts provided a resource on which the participants *juxtaposed* and configured their local interactional practices and developed competencies for experimentation and meaning making in a laboratory science activity. Uptake was used to describe the interaction contingencies that were observed and to demonstrate how contingencies scale across the embodied, physical, semiotic, and temporal facets of the setting. We observe that practices are made accountable and support the development of group-level competencies. In our data we conclude (a) that persistent inscriptions provide a durable semiotic resource for making instantiations of relevant and emergent components of a problem (Alac & Hutchins, 2004; Koschmann et al., 2006). That is, salient aspects can be located or are "locatable in the setting" and are consequential to how a group proceeds and (b) that uptake across modes (modal transposition) requires mutable surfaces for any action to perform a transformation in the setting. Thus, uptake is dramatically facilitated by opportunities for distributed interaction across mutable media.

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