The Long & Winding Road to Collaborative Observational Practice

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Abstract: A central challenge of observational practice is to reach agreements about what an individual sees with what others see. We used a case study to trace how computer tools—in concert with small group and whole class discussions—mediate collaborative observational agreements in a middle school classroom. Results suggested that shifting conceptions of nutrients affected student observations. Our analysis examines how this was temporally, materially, and socially mediated leading to convergence in observations and understanding.

Observation is fundamental to scientific practice and to how scientists generate new knowledge. A central challenge of observational practice is to reach agreements about what an individual sees with what others see (Daston, 2008). To address this challenge, scientists have forged cultural tools—language, equipment, and disciplinary systems of knowledge and practice—that enable the collaborative construction of shared vision (Goodwin, 1994). Although observation plays a central role in science, we know little about how novice observers develop into scientific observers (Eberbach & Crowley, 2009) and how computer tools might support such development. In this paper, we explore how computer tools mediate middle school students' agreements, observations, and knowledge of nutrients in a pond ecosystem. We do this by examining the collaborative observational practices that facilitate agreements about observed phenomena.

Methods

This study is part of a program of design research that develops and explores computer-based instructional interventions that mediate middle school student understanding of natural systems (Hmelo-Silver, et al., 2011). The context for this analysis was a 6-week unit on aquatic ecosystems. The unit was organized around the problem of fish dying suddenly in a local pond. Working in small groups, students engaged in inquiry by using assorted scientific evidence, including computer simulations, a computer modeling tool, authentic data, and student worksheets. Video data and student-generated artifacts served as our primary data sources. Although we generally focused on one group of four students, we made forays into whole class interactions to trace the path that students took to achieve shared understanding of *nutrients* in a way that enabled collaborative observation of scientifically meaningful patterns.

Results and Discussion

In the results we show how complex interactions among small groups, whole class discussions, and interactions with various tools led to collaborative construction of shared meaning of *nutrients* in a pond ecosystem (See Figure 1).

Questions about the meaning of *nutrients* first surfaced during our group's interactions with a simulation that enabled students to explore relations between populations (algae, fish), environmental factors (sunlight, nutrient runoff), and levels of CO_2 and O_2 in a pond ecosystem. Like many novices, this group conflated the term *nutrients* with food, which affected what they expected to observe in the simulation. Conceptualizing *nutrients* to be essentially good for fish, they maximized the amount of nutrients into the pond but were surprised by what they observed: "It's weird that they live longer with less nutrients but they live shorter with less nutrients. So nutrients are bad?" In attempt to make sense of these results, the students repeatedly manipulated the simulation, observed similar results, and grudgingly recorded their findings in their worksheets. Near the end of this session, the teacher initiated a whole class discussion "to make sure they have the same understanding of the simulation." This discussion revealed little agreement about what constituted *nutrients*: Students typically described *nutrients* as food, animal waste, or fertilizer, whereas the teacher characterized *nutrients* as chemicals that support life processes.

The following day, the group continued to explore the simulation and to revise their computer model to explain why the fish died in the pond. They agreed to include several system relations, including those that connected photosynthesis with algae, oxygen, and water temperature. The group also agreed to include *nutrients*, but did so in a way that isolated *nutrients* from the rest of the model, suggesting that *nutrients* was something of a black box. The question for the students remained, "If it isn't food, then what is it?"

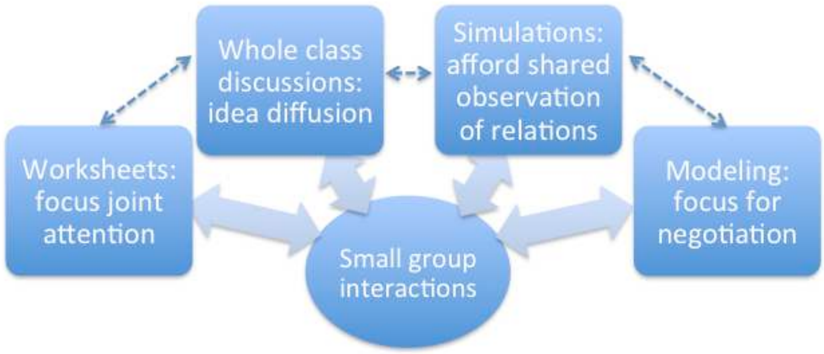

Figure 1. This model shows the many pathways to constructing collaborative agreements about the meaning of nutrients in a pond ecosystem. Convergent conceptual change is mediated by observational practice, which is distributed across time, social interactions, and material resources.

In practice, the teacher's observations were substantially different from those of the students: She observed functional relations at a micro-level (i.e., chemical) whereas they saw structures in isolation. But as students continued to manipulate other simulations featuring micro-level processes (e.g., decomposition, nitrification), complete worksheets that narrowed their observations of the simulations, negotiate modeling decisions, and participate in discussions they slowly began to reach certain agreements about what constitutes *nutrients* ("Decomposers make *nutrients* from dead matter"). Agreeing among themselves that *nutrients* are micro level structures that involve micro-level processes also brought them in closer alignment with how the teacher conceptualized *nutrients*. In time, the group eventually decided to move *nutrients* into the model proper, connecting them to decomposers and fish with a vague claim that "the *nutrients* are affecting the fish in some way."

In conclusion, the path to reaching agreements that enable seeing what others see was neither straight nor simple. Technology offers opportunities for conceptual convergence as learners have opportunities to display, negotiate, and repair their ideas (Roschelle, 1992). Thus, engaging with simulations and modeling tools as well as whole class and small group discussions mediated agreements. The simulations and small group discussions were occasions for individual groups to engage in collaborative observational practices and for negotiating what they had noticed through disciplinary content. The whole class discussions provided a context where the teacher could help learners develop and apply appropriate disciplinary lenses. The model was the place for students to make their thinking visible and to articulate their expectations about the meaning and role of nutrients in the pond ecosystem. These agreements transcended simply naming objects to describe behavior or form, but enabled learners to agree on shared observation of patterns of form, function, and process. The implications of our analysis suggest that the long and winding road of convergent conceptual change is mediated by observational practice and that this practice is distributed across time, tools, and social interactions.

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