E. PDAS AND UBIQUITOUS COMPUTING

The Impact of Distributed and Ubiquitous Computational Devices on the Collaborative Learning Environment

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ABSTRACT
Recent advances in small, personalized computing devices have made possible distributed and ubiquitous computing within the classroom. This creates a fundamentally different environment from one that has 4 or 5 desktop machines per classroom (Soloway et al., 2001). In this paper we sketch out the impact that Thinking Tags can have on the teaching and learning environment.

Keywords
Participatory Simulations, Wearables, Decentralized Systems, Distributed Computing, Collaborative Discourse

INTRODUCTION
Participatory Simulations use small, wearable computers to involve people in simulations that are mediated, in part, by technology (Colella, 2000). Each participant wears a small computer, called a Thinking Tag (Borovoy et al., 1996), that executes rules and keeps track of important information during the simulation. The computers themselves are brightly decorated with legos and are adorned with two displays – a two-digit LED and a series of 5 colored LEDs. The devices communicate through infrared, and are extremely simple, making them almost transparent to the participants during the simulation. The simulation results from the interactions between the rules that are programmed into the computers and adopted behavior. For instance, in the first activity developed for this platform, participants met each other and information was passed that may have infected an individual's tag. Working collaboratively, students determined the rules by which the virus starts and gets passed around.

Colella's research has shown that this technology can simultaneously engage a wide range of students in scientific investigation and discovery. To capitalize on the potential of these tools and further the research we have developed new simulations for this platform. These include:

- *Big Fish Little Fish* immerses participants in the fight for survival, as little fish scavenge for food and big fish attack little fish, and provokes an examination of the roles of collaboration and competition in systems.
- *Tit for Tat* allows participants to investigate how cooperation can evolve in communities over time as they play the classic Prisoner's Dilemma with each other to try to gain the most points.
- *Dental Health* encourages children, through kinetic make-believe, to mingle about the room and "snack" on foods or "brush" to get their teeth clean. Lights on a thinking tag display healthy and diseased imaginary teeth. The goal is to maintain healthy teeth throughout the game
- *Genetics* engages students in a simulated inheritance situation. Each Tag is pre-programmed with a genotype that is to be discerned by students as they meet with other Tags and observe the total probability and random selection of eye colour resulting from each encounter.
- *Issues Based Science* uses the Tags to publicly display the stance and values students hold on the issue of genetically modified foods. Students use this public information to decide whom they wish to try and convert to their position.

CLASSROOM IMPLEMENTATION
Currently, the goals for the Thinking Tag technology are two fold: (1) to investigate how teachers can use the Tags to improve science teaching, and (2) to explore how the Tags can help us understand the collaborative learning process.

Addressing the first goal, we have developed strategies to help teachers create more powerful learning experiences for their students. Our experience with the StarLogo Community of Learners workshops (Colella, et al., 1999) in which we teach teachers to develop their own models of complex, dynamic systems using StarLogo suggests that this is an effective professional development strategy. Clearly, for one teacher, the workshop pinpointed the beginning of his involvement with integrating technology into his classroom, "…When we both saw the kind of scientific thinking and redesigning and re-experimenting and re-editing which we don't have time to do—or don't take time to do—in our labs. We could, but we don't. [With the tags] the kids could change their variables in any way they wanted to, and that was an incredibly powerful experience for them." Another teacher combined the Tit for Tat game with computer simulations and a game in which the students had to develop cooperative strategies in order to consume the most M&Ms using four-foot long spoons. This combination created collaborative discourse unlike any that the teacher had seen before. Students brought in references from history, social science and even the popular show "Survivor" in which they described the first season's winner as a "defector" and the second season's winner as a "cooperator." Yet another teacher ran the disease simulation in his seventh and eighth grade science classes over three days. However, unlike in our workshop where the primary goal of the activity is to gain a deeper understanding of systems, this teacher adapted the activity to fit into a unit on epidemiology and combined the tag activity with related written assignments on specific diseases. This activity generated interest on the part of both the teacher and the students to create a modified version of the disease game to reflect characteristics of other viruses.

Our second goal of using the Tags to explore collaborative learning processes points to three emerging themes. The first is that the Tags make some of the covert collaborative process in social constructed knowledge overt. When 4 and 5-year old children were involved in the dental health activity it became apparent that they were watching what happened to each other's tags. On the surface their behavior appeared very individualistic and non-collaborative. Closer examination indicated, however, they were using the collective data to form their ideas about when to brush and the consequences certain foods had on one's teeth. The second theme is that the public display of first-person information on the tags highlights interactions between the affective and cognitive domains. Students in the issues based science activity, for example, became visibly nervous when another student approached them displaying a tag that indicated no one had managed to change her mind. "She's scary!" one of the group noted as they tried to avoid talking to her. The third theme features the role of evidence in what Scardamalia has called epistemic agency. Epistemic agency involves assumption of control over one's knowledge-building processes. Participants in the genetics simulation activity give us some insight into this process when they overtly formulate critical hypotheses and then seek individuals with tags that will give them the data they need.

NEXT STEPS

As distributed and ubiquitous computing devices become more common place, other researchers (Soloway et al., 2001; Wilensky & Stroup, 1999) are porting similar activities to more common devices such as Palm OS devices and programmable calculators. Therefore, one of our next steps is to systematically analyze how the Tag specific affordances impacts collaboration. At this point we conjecture that the unobtrusive, fun, simple and non-technical nature of the tags can provide a qualitatively different experience for the participants.

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