

## **Embedded Phenomena for Knowledge Communities: Supporting complex practices and interactions within a community of inquiry in the elementary science classroom**

Rebecca Cober<sup>1</sup>, Cresencia Fong<sup>1</sup>, Alessandro Gnoli<sup>2</sup>, Brenda López Silva<sup>2</sup>, Michelle Lui<sup>1</sup>,  
Cheryl Madeira<sup>1</sup>, Colin McCann<sup>1</sup>, Tom Moher<sup>2</sup>, Jim Slotta<sup>1</sup>, and Mike Tissenbaum<sup>1</sup>

<sup>1</sup> Ontario Institute for Studies in Education, University of Toronto

<sup>2</sup> Department of Computer Science and Learning Science Research Institute, University of Illinois at Chicago  
rebecca.cober@utoronto.ca, cresencia.fong@utoronto.ca, agnoli2@uic.edu, brenda.ls@gmail.com,  
michelle.lui@gmail.com, madeirc@gmail.com, colindmccann@gmail.com, moher@uic.edu, jslotta@gmail.com,  
miketissenbaum@gmail.com

**Abstract:** The work presented here is a product of a collaborative effort to develop a knowledge community and inquiry curriculum for elementary science, where students engage in extended investigations of simulated scientific phenomena presumed to occupy the physical space of their classrooms. By their immersive nature, these “embedded phenomena” lend themselves to a collective epistemology, and hence to new forms of learning and instruction that depart from the conventional didactic approach. The symposium centers on the design and enactment of a seven-week elementary school ecosystems unit, WallCology, developed in close collaboration with partner teachers and school administrators during summer and fall of 2011. Six posters highlight different facets of our effort, including descriptions of the immersive environment, the instructional narrative, the inquiry support technologies, the role of aggregate representations, discourse processes, and the classroom experiences of the 37 students and two teachers who participated in the unit.

### **Introduction**

The goal of establishing a science classroom where students and teachers work together as a community of learners has been championed by Brown and Campione (1996), Scardmalia and Bereiter (1996; 2006), Bielaczyk & Collins (2006) and many others. In this vision, student’s work together with peers to investigate issues or phenomenon, develop their own theories, build upon one another’s ideas, and make progress toward some commonly held learning goal. While this “knowledge community approach” (Slotta & Najafi, 2010) has received many accolades for its vision of a collective epistemology, it has been quite difficult for researchers to enact. The FCL approach (Brown & Campione, 1996) has never been fully replicated, and the knowledge building model has been recognized by Scardamalia (2006) and others (van Aalst & Chan, 2008) as being quite challenging to enact.

What are some of the major obstacles to making a knowledge community approach more tractable for researchers and practitioners alike? First, there must be some object of inquiry. The design or selection of this object of inquiry is of crucial importance, as it must be sufficiently intriguing for students, accessible to their investigations, and broad enough in scope to ensure that all students must be involved to make progress in the inquiry. Second, there must be pedagogical and technological scaffolds to support student inquiry, allowing students to engage in authentic science practices and helping make ideas visible for students, peers and teachers. Such scaffolds, when well designed, help students focus on important scientific aspects of the inquiry objective. Third, a community knowledge base serves to captures the aggregated observations and insights of all participants, and serves as a resource to their subsequent inquiry. Finally, there is an important epistemological element, where students must come to understand the purpose of their inquiry as being quite different from “individual learning,” and instead more concerned with the progress of the whole class in terms of inquiry activities and theoretical ideas. These are extremely important theoretical constructs in the learning sciences that are fundamentally distinct from the dominant body of work that explores individual learning, or even the more conventional models of collaborative learning. These ideas represent a revolutionary departure from conventional instruction, and a step toward inclusive, equitable, engaging designs—if only we can get past the substantial barriers to entry. We must assume that our own understanding about how to conduct such research will grow in parallel with our scientific output, as we observe and participate in the evolution of learning and instruction within our partner classrooms. Perhaps this is why such research remains limited to just a few exemplars, despite its compelling theoretical position.

The work presented here is a product of a new collaborative effort to engage in a knowledge community approach in an elementary classroom. One group, led by Tom Moher at the University of Illinois at Chicago, has spent the past six years developing a design framework called Embedded Phenomena (Moher, 2006), which engages learners in extended investigations of simulated scientific phenomena presumed to occupy the space of their classrooms. By their immersive nature, these embedded phenomena lend themselves to a collective epistemology, and hence to new forms of learning and instruction that depart from the conventional

didactic approach. The other group, led by Jim Slotta from the University of Toronto, has developed a new pedagogical model called Knowledge Community and Inquiry (KCI) that provides a scaffolding framework for collective inquiry (Slotta, 2007). The project seeks to enrich the representational space of the embedded phenomena framework with the addition of comprehensive inquiry support layer for students' and teachers' enactment of complex investigations.

The symposium centers on the design and enactment of a seven-week elementary school ecosystems unit, WallCology, developed in close collaboration with partner teachers and school administrators during summer and fall of 2011. Six posters highlight different facets of that process, including descriptions of the immersive environment, the instructional narrative, the inquiry support technologies, and the classroom experiences of the 37 students and two teachers who participated in the unit. The symposium will begin with a fifteen-minute overview to orient participants to the poster suite, followed by an hour of individual discussion with poster presenters. Chris Quintana from the University of Michigan will serve as chair and discussant, offering comments during the final fifteen minutes of the symposium.

## WallCology: Representational space and instructional narrative

Brenda López Silva, Alessandro Gnoli, and Tom Moher

In WallCology, learners are challenged to maintain the biodiversity of a simulated ecosystem contained within a controlled environment imagined to occupy the walls of their classroom. The ecosystem contains several species of flora and fauna which students observe through persistent (continuously animated) portals ("WallScopes") attached to the walls of the classroom, allowing them partial access to the controlled habitats. In addition, students are given control over several environmental variables that differentially impact vegetation growth: temperature, humidity, and lighting (Fig. 1). While initially stable, over the course of seven weeks, the ecosystem is perturbed in ways that threaten the viability of one or more species. Students are asked to respond to threat through the manipulation of the environmental controls, based on their understanding of the system food web and population dynamics.

Students engage in a progressive series of activities designed to foster learning across a range of ecosystem concepts and science practices. Initially, students document the *biodiversity and abundance* of the system through systematic observation of habitats and species that they see in the WallScopes. In the second phase, students focus on identifying the *life cycles* of the animal species by observing egg hatchings, transitions from larvae to pupa, etc. These understandings are needed in order for students to *estimate species populations*, an activity that is repeated periodically throughout the unit in order to monitor population trends that are not readily apparent to the naked eye. (Population estimates are obtained by "counting" species visible within the WallScopes and computing estimates based on the ratio of the area of the classroom wall to that of the display screens). Students observe the feeding patterns of species in order to construct the *food web* defining the indirect interactions within the ecosystem.

An initial perturbation (the "failure" of the lighting system in several of the habitats), and its concomitant impact on population levels, alerts the children to the sensitivity of the system. While this "failure" is quickly resolved, it creates an opportunity to engage the learners in consideration of "what-if" scenarios involving other potential threats to the system. Rather than experimenting on the target ecosystem directly and risking possible catastrophic results, learners are provided with an *ecosystem-modeling* tool that allows them to rapidly model outcomes associated with variations in population mixtures and environmental conditions. The *community knowledge* growing out of this phase becomes critical when a second perturbation is introduced: the arrival of an invasive species in the form of a new predator. In the final phase of the unit, students directly intervene in the WallCology ecosystem by modifying environmental conditions to mitigate the impact of the predator and ensure the survival of all of the original species.

Student activity within the unit involves a combination of structured observation, question and hypothesis formulation, experimental manipulation and hypothesis testing, and whole class and small group discussion, all within the context of a technology tool suite that allows students and teachers to contribute to, and draw from, an emerging community knowledge base. Students record observations, utilize the modeling tool, and synthesize contributions to the knowledge base using tablet computers; teachers orchestrate discussions using a SmartBoard interface that gives them access the knowledge base and scaffolds themed discussions aligned with unit milestones.



Figure 1. "WallScope" view of a WallCology

## Smart Classrooms for Knowledge Communities: EPIC Technology Environment

Jim Slotta, Mike Tissenbaum, Michelle Lui, and Matt Zukowski

New forms of knowledge media offer a wealth of opportunity for researchers who can take advantage of the varying contexts (i.e., within the classroom, at home, or in field activities) and devices (e.g., laptops, smartphones, interactive tabletops, and large format displays) to design exciting new kinds of instruction where students dynamically generate knowledge, build on peers' ideas, and investigate questions as a knowledge community. We have advanced the notion of a "smart classroom," which integrates such technologies for purposes of supporting a spectrum of collaborative inquiry and knowledge construction activities. The work centers around the development of a flexible open source platform called SAIL Smart Space (S3), which offers a framework for integrating devices, materials, and user interactions, as well as a set of core technologies: (1) a portal for student registration and software application management; (2) an intelligent agent framework for data mining and tracking of student interactions in real time; (3) a central database that houses the designed curriculums and the products of student interactions; and (4) a visualization layer that controls how materials are presented to students (Slotta, 2010).

We have implemented S3 in several distinct scenarios, including (1) PLACE. Web: a content community for high school physics (Tissenbaum & Slotta, 2011); (2) EvoRoom: an immersive, room-sized simulation of a Sumatran rainforest where students investigate evolution (Lui, Tissenbaum & Slotta, 2011), and (presently) (3) Embedded Phenomena for Inquiry Communities, where tablet computers and shared interactive displays support student investigations of simulations running within their classroom walls, floors and ceilings. Through these developments, we investigate how smart classrooms can scaffold the collection, aggregation, and representation of information across contexts and environments. We also strengthen the underlying S3 "core technologies" so they may be extended to an increasing range of applications. Our poster will detail the S3 implementation for the EPIC designs. We focus on several dimensions, including the role of the core technology (e.g., to register students, support groups, store and retrieve data, etc), our use of intelligent agents (i.e., in support of the various interaction designs discussed in other posters within this session), and the specific forms of visualization used for various purposes.

Our Wallcology enactment relied on two loosely coupled systems: (1) the Embedded Phenomena server, which managed the bug colonies (and all perturbations, environmental dependencies, etc.) within the classroom walls, and (2) an S3 server that supported student and teacher interactions, including log-ins, data collection and management, tablet and Smartboard applications. S3 supported our development of a peer-to-peer network of tablet-based input devices, where students add their observations of the phenomenon (e.g., counts of species appearing on the wallsopes), as well as more abstract representations (e.g., the relationships between two species of insects). Observational data are aggregated in real time, using Extensible Messaging and Presence Protocol (XMPP), which updates student tablets continuously. Intelligent agents are also implemented using XMPP; agents are implemented as software routines that simply "listen in" to the relevant message stream, and take action whenever certain conditions occur. WallCology employs an Archivist agent, which translates incoming messages from the tablets into database entries, and a Notetaker agent, which passes student notes from tablet to database and to the Smartboard. Several distinct forms of representation were designed, including aggregate tables of student observations, graphical representations (e.g., of species counts, dependencies across locations in the room, etc.), and the phenomenon itself – both in a concrete form (i.e., "1 bug in the wall is 1 bug on the screen") and a more symbolic form (graphs of bug populations). The representations were populated by active calls to the database that occurred via XMPP in real time, so that all tablets and the Smartboard were updated instantaneously. Our poster will discuss the role of smart classroom technologies in supporting research of complex pedagogical designs, including the scaffolding of interactions, as well as distinct affordances for real time aggregation and execution of pedagogical logic (e.g., dynamic grouping, real time assignment of resources, and content sensitive feedback), using intelligent agents. S3 offered an accessible means of developing the sophisticated array of interdependent applications needed to coordinate our Wallcology designs.

**Materials that scaffold collective inquiry: The role of aggregate representations**  
Rebecca Cober, Colin McCann, Jim Slotta, and Tom Moher

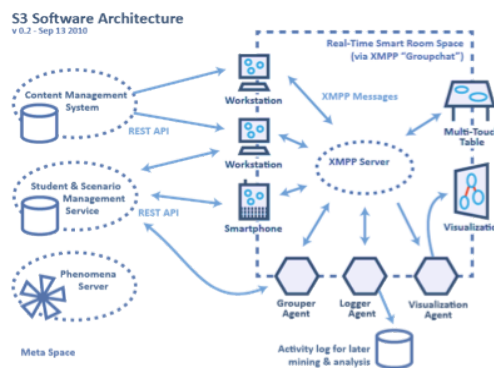


Figure 2. The S3 Software Architecture.

In previous enactments of WallCology, students used paper lab books to record observations about the phenomena (Moher et al., 2008). In the current version, our interest was to help students work collectively as a "knowledge community," with the contributions of individuals or small groups readily accessible to others. Moreover, the results of individual inquiry actions, such as observations or reflections, should ideally combine into aggregate representations (ARs) that make important patterns visible to both teachers and students.

To achieve this goal, we developed a new technology layer to support student investigations and to share knowledge with each other. A custom tablet application was developed to support student investigations of WallCology, effectively replacing the lab books of previous iterations. Most importantly, students had access to ARs, displayed on the tablets and interactive whiteboards, comprised of their own and their peers' observations and insights, compiled in real-time using XMPP (a Twitter-like messaging technology). Our presentation will describe the design and evaluation of these representations and the role they played within the WallCology narrative. Our guiding research question: *How do aggregate representations of collective knowledge advance students' and teachers' understanding of the object of scientific inquiry and provide a resource for subsequent inquiry activities?*

**Method.** Our designs were informed by the Knowledge Community and Inquiry (KCI) framework, which seeks to integrate elements of community knowledge construction with scaffolded inquiry (Slotta, 2007). We designed a tablet application to facilitate four learning activities within the WallCology unit: recording observations of (1) the organisms and (2) habitats of the ecosystem, and constructing representations of (3) life cycles and (4) food webs (Fig. 3).



**Figure 3.** Aggregate representations of community knowledge. Text-based data tables for learning activities 1 and 2, and pair-wise matrices depicting tallies of relational statements, for learning activity 4.

We begin by describing the targeted pedagogical goal for each AR, in relation to its corresponding learning activity. We then evaluate each AR in the context of the wider instructional design: does it serve to achieve the broader desired pedagogical goals of the unit? Next, we evaluate the enactment of the curriculum, recognizing that it may diverge considerably from the intended design, due to variations in teaching styles and classroom dynamics. Finally, for each AR, we capture and represent the pedagogical patterns that actually occurred in this iteration of WallCology, and compare them against our original design goals.

**Outcomes.** The AR designs supported collective inquiry in three important ways. *First*, teachers used the ARs to guide whole-class discussions (WCDs). One pattern, called "aggregate observations and discuss" occurred across all four ARs, where teachers displayed relevant strands of student-contributed observations to facilitate discussion, moving the classroom inquiry toward a desired pedagogical goal. The outcome of these WCDs frequently set the stage for further work, revealing important next steps in the investigation of the EP. *Second*, ARs were used to form a basis for consensus – particularly the relationship tallies in ARs 3 and 4. High tallies were strong indicators of the veracity of relational statements (e.g., that green bugs hatch from dark blue eggs), enabling the community to resolve the life cycle and food web relationships (led by the teacher). *Third*, the ARs revealed areas of disagreement, moving the "knowledge community" forward in their understanding of the embedded phenomena. Closely contested observations (e.g., two organisms tallied almost equally for the same life cycle stage) were readily apparent in the ARs, providing specific areas for students to focus on in their continued investigations, and for teachers to focus discussions.

## The Role of Discussion in Orchestrating Inquiry

Crescencia Fong, Rafael Pascual-Leone, and Jim Slotta

WallCology engages students in cognitive, social, and technological interactions with their environment orchestrated by the teacher, typically through discussions that served to advance the understanding of the community. *How do such “idea-centred” (Scardamalia & Bereiter, 1996) discussions proceed? How should the teacher “orchestrate” (Fischer & Dillenbourg, 2006) and “script” (Kollar, Fischer & Slotta, 2007) such discussions to foster students’ sense of contribution and personal progress? What role does technology play in representing student ideas, and supporting the growth of collective understanding?* We investigate those questions by examining discussions that occur within WallCology classrooms, describing: (1) the pedagogical characteristics of discussions that occur throughout the unit, (2) how the various WallCology technologies were employed within those discussions, and (3) how a new discourse tool impacted those pedagogical characteristics. We begin by analyzing the discussions that occurred in each classroom. We then introduce “Common Knowledge” (CK)—a technology environment designed to promote idea growth and exchange while enabling teachers to guide discussions.

**Method.** In WallCology, the teacher’s role as ‘guide on the side’ is pivotal in facilitating meaningful discussions. Such discussions may be short and spontaneous to orient students toward productive paths, or lengthier and strategically placed in the curriculum to promote conceptual learning goals. Using video and observation notes, we analyzed discussions occurring during the first month of the enactment, in terms of their goal or purpose, conversational dynamics, the growth of ideas, and pedagogical outcomes or consequences. We also analyzed the use of technology and paper-based resources.

In CK, a handheld computer tablet application enables students to contribute their questions, evidence-based hypotheses, theories, and ideas; and “tag” their contributions from a list of science content and practice keywords (e.g., “Theory”, “Observation”, “Question”). These notes dynamically appear on all tablets and on the classroom’s SMART Board, allowing teachers to manipulate notes during oral discussions, swiftly filtering topic-related notes as the discussion progresses. We integrated CK discussions into the WallCology curriculum, specifying discussion goals and pre-programming relevant keyword tags. Teachers also launched spontaneous CK discussions, as they felt warranted.

**Outcomes.** Four WallCology sessions in both grades 5/6 classrooms were analyzed as described above. Data sources included classroom observations, video and audio recordings, teacher-researcher debriefings, paper artifacts of student work, teacher and student interviews, and data logs of CK discussions. The goal was to produce a schema for productive inquiry discourse, and a model by which to evaluate CK discussions. Discussion analysis revealed several distinct discourse patterns, including:

- *Encouraging new ideas.* Teacher displays observation data or CK notes on SMART board; helps students recognize that there might be additional avenues for reflection or observation;
- *Resolving divergence.* Teacher displays observation data or CK notes on SMART board; helps students notice divergence, discuss each position, and consider ways to resolve the divergence;
- *Introduce topics or processes.* Teacher builds upon existing ideas from observation data or CK notes, grouping ideas together to promote insights about a new topic (e.g., organism life cycles);
- *Motivate approaches.* Teacher encourages students to reflect on data or hypotheses, brainstorm limitations to current approaches, and possible new activities (e.g., comparing numbers of species in different habitats).

We analyzed the CK discussions that occurred within the first 4 weeks of the WallCology curriculum, to see how teachers achieved these patterns using the technology environment. Students were engaged, with 4 times the number of in-class CK contributions per minute than oral discussions, and substantial reading and response to peer notes. Idea growth and symmetric knowledge advance were heavily reliant on teacher orchestration of lesson activities and spontaneous teacher scaffolding. Design improvements are concerned with smarter filtering and commenting.

## Teacher Orchestration of Complex Inquiry Patterns

Cheryl Madeira, Crescencia Fong, and Richard Messina

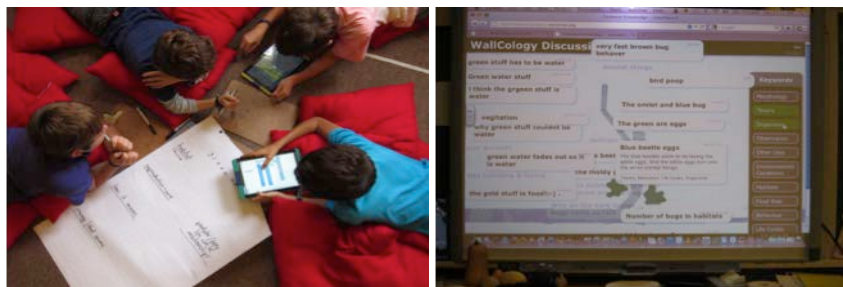


Figure 4. Tablet (left) and SMART Board (right) mediated discussions.

How do teachers orchestrate complex inquiry-based activities, and how can technology scaffolds be developed that support teachers as they acquire such skills? This paper examines teacher practice within the Wallcology project, following two master teachers as they worked closely with researchers and technologists to co-design, enact, and revise (often in real time) the inquiry-based activity patterns for their grade 5-6 classes. Indeed, from the outset, these teachers (“knowing better”) asserted that it would not be possible to choreograph every twist and turn of the curriculum, but that they would need substantial leeway to interpret the situation and respond accordingly. Such “adaptive practice,” illustrated below, can be viewed as “orchestration” of an inquiry design:

After reviewing the day’s lesson plan, the teacher, Brendon (pseudonym), notices that students have not entered details in their Observation tab. He says, “*Only a couple of notes on life cycle were entered... maybe today we can observe more.*” Then he instructs: “*under the Organism tab, you can talk about organism again; and then go into life cycle.*” Even though the plan had called for whole class session of Observation of organisms, Brendon realized that by turning kids’ attention forward to “Lifecycle observations,” he could transition into the important step of “Relationships”. (*FieldNotes 2011\_1017*).

This excerpt illustrates adaptive teacher practice, where the teacher gauges students' prior knowledge (Penuel & Gallagher, 2009), develops collaborative opportunities for students' inquiry processes (Slotta & Linn, 2009), and facilitates students' emerging knowledge (Zhang et al., 2010). In recent years, learning scientists have embraced the term 'orchestration,' defined as “*the process of productively coordinating supportive interventions across multiple learning activities occurring at multiple social levels*” (Fischer & Dillenbourg, 2006). In orchestrating the flow of activities, materials, and interactions within the classroom, teachers develop pedagogical knowledge.

Method. To capture the role of the teacher in our EPIC classrooms, we examined teachers’ orchestration, including their adaptive responses to student ideas, and how they make use of technology in ways both intended (i.e., by designers) and unintended. While the teachers in our study were both masters of inquiry-based pedagogy, having used it exclusively for 3 and 5 years respectively, neither had any experience with embedded phenomena nor the specific forms of student inquiry it was designed to support. Thus, while our teachers entered with substantive pedagogical knowledge, there would be many challenging and novel aspects of teaching with the Wallcology materials and activities. Our research seeks to understand how these teachers develop new practices (and implicitly, new pedagogical knowledge), and to inform our understanding of how such orchestration leads to in-service professional development.

We observed the teachers throughout the co-design and enactment of the 8-week Wallcology unit that addressed science topics related the diversity of life. Data included classroom observation notes, video, photos and audio recordings, time logs of teacher’s activities, teacher and student interviews, and other relevant school documentation. Ten co-design sessions were held (all audiotaped) where teachers, administrators, researchers and technologists designed the curriculum activities, reviewed drafts of materials and technology tools, and reflected actively about the nature of learning and instruction with Wallcology. We observed all classroom sessions, and debriefed regularly with teachers, including larger scale research meetings where the teachers met with the entire research team to discuss pedagogical issues and inform ongoing design. Working first from observation notes, then from video, we segmented each lesson into an “orchestrational move.” For each segment, we described the purpose, or goal, the role of technologies or representations, and any consequential outcomes. We paid particular attention for “adaptive moves” where teachers responded to characteristics of the classroom, evidence of student knowledge, or intuitions about where more attention might be necessary.

Outcomes. It became apparent early in the implementation that the teachers were not at ease unless they were able to adapt and improvise at any moment during the enactment. They felt strongly about their decisions to veer away from certain design requirements. We saw evidence of teachers ignoring the technology when face-to-face communications were more comfortable and effective. In one segment after the next, there were indications that teachers assessed student engagement and understanding, then responding in ways that departed from the lesson plan. Each night, a revised lesson plan was made for the following day. While we had envisioned that the plan would be a reference guide (expecting some variance), Brendon commented that he “had the score in his head” – summoning images of a “jazz performance” rather than “orchestral conducting.” At least for these early trials, our curriculum was specified more as a series of “chord progressions” than a strict melody. Our summary of teacher enactment patterns, including technology use, can inform the design of EPIC curriculum to reinforce those patterns and encourage teachers with less expertise to engage in them.

## Fidelity of science practice in complex instructional designs

Alessandro Gnoli, Cheryl Madeira, Tom Moher

Contemporary research in science pedagogy emphasizes the importance of engaging learners in authentic science practices, not only for the development of specific inquiry skills, but also for the development of agency and understandings about the nature of scientific work (Duschl, Schweingruber, & Shouse, 2007; Zimmerman, 2007). The embedded phenomena (EP) framework affords classroom learners opportunities to engage in a broad range of science practices, particularly the kind of “patient science”—extended inquiry over long time periods—that elementary school students rarely encounter (Fulp, 2002). The underlying simulations are designed to present an extended narrative, gradually revealed through the accumulation of data over time. The clarity of that narrative, as a result, is highly sensitive to students’ consistent and accurate applications of observational and manipulative procedures, making the timely detection and remediation of practice errors critical capabilities in successful enactment. When errors—of observation, of computation, of transcription, of interpretation—go undetected, and erroneous data are added to the historical representation of the investigation, they can obscure the underlying narrative of the unit, undermining days or weeks of classroom effort.

In WallCology, students gather and transcribe substantial amounts of “objective” data involving habitats, life cycle patterns, producer/consumer relationships, and environmental conditions. They “count” individual animals within WallScopes (samples) and computer population estimates based on physical measurements of the classroom walls. Errors in these practices can have significant impacts on the resultant representations used by students to reason about the state of the ecosystem. For example, an incorrect characterization of the life cycle of one species can result in incorrect classification of individuals within sampling activities, leading to population estimation errors. Inconsistent procedures for counting individuals (even if properly classified), or computational errors in determining count averages can have similar effects. In WallCology, the cumulative impact of these errors can easily mask population shifts or introduce representational artifacts unrepresentative of the actual state of the ecosystem.



**Figure 5.** Errors in counting mask important population trends in prior WallCology enactment.

**Method.** Moving embedded phenomena from paper to technology-based media creates the opportunity to identify observational, transcription, and computational errors of practice at the point of data entry. While straightforward enough to implement, our goal is not to use discrepancies as the basis for directly notifying students of their errors (e.g., using pop-up dialogs to inform students that the data they just recorded are incorrect). Rather, our longer-term strategy is provide notifications to *teachers*, who can use the information to more subtly intervene within undermining students’ agency as investigators (e.g., by walking over to a group that’s making significant errors in practice and suggesting that their data seem unusual, perhaps warranting a “second look” by the group). Research surrounding this strategy will focus on the capacity of teachers to manage this information flow, the choice of media to be used for delivery (e.g., tablet notifications, smartphone text messages, Bluetooth earphones), message representations (individual, small group, whole class), and information origination (e.g., “push” vs. “query” strategies).

**Outcomes.** We have developed software agents that continuously compare student data entries with the current state of the simulation, and we used those agents to collect baseline data on the frequency and magnitude of errors during the present WallCology enactment. Preliminary analysis suggests that moving to electronic rather than paper-based media has not impacted the rate of practice errors. As in prior enactments, cumulative errors obscured the representation of population trends, requiring us to “dramatize” the impact of ecosystem perturbations in order to motivate population modeling and interventions.

The rate of observed errors suggests that the design of notification mechanisms could be a significant challenge, requiring a careful balance between real-time and off-line approaches, and the adoption of strategies that are sensitive to the severity of errors as well as historical error frequency among individuals and within groups. We will be designing and developing our initial tools and procedures to support practice error notification and remediation for a second iteration of the “new” WallCology in spring 2012.

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