‘Hybrid Modeling’: Advanced Scientific Investigations Linking Computer Models and Real-World Sensing (an interactive poster)

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Abstract: ‘Hybrid modeling’ is an innovative technological platform that enables students to link multi-agent models (“in” the computer) and electronic sensors (“outside”) in real time. The platform is designed for learners to validate, refine, and debug their computer models using real-world data. Also, the technology broadens the types of scientific explorations possible in classrooms. Pilot studies suggest a real-to-virtual reciprocity that catalyzes further inquiry toward deeper understanding.

What do we obtain from “going out to the world” as a learning resource? Multiple aspects of such learning experiences have been explored by different schools of thought in education. John Dewey (1916) was one of the first to emphasize the importance of connecting school learning and real-world experiences. Critical pedagogy and situated-learning advocates argue that departing from the learner’s out-of-school context is crucial to foster emancipating and motivating learning (Freire, 1974; Lave & Wenger, 1991). Constructionist educators (Papert, 1991) posit that building personally-meaningful public artifacts is central to promote sustainable and deep learner engagement. However, does the world afford the necessary information and opportunities for students to learn the ‘official’ school content? For instance, are acid-base reactions amenable for student inquiry? School laboratories, as we explain, do not always provide the necessary solutions.

While concurring with claims about the relevance of the learner’s context, background, and concrete experiences for education design, we acknowledge that the current tools for scientific exploration available for students limit the domains and complexity of their real-world investigations. Thus, we submit that the disconnect between what one could potentially learn in a situated environment and the more traditional school content may be due to the lack of appropriate tools to ‘dissect’ reality to the appropriate level of analysis. Even if, by definition, Physics, Chemistry, and Biology are ‘out-there’ in the world, most phenomena are invisible to human vision and time scale. Many patterns in nature are too long, too fast, too small, or too large for learners to extract and understand the underlying structures. Canonical examples are weather behavior, chemical reactions, housing and traffic patterns, particle physics, and population ecology. Conventional school laboratories are not well equipped to support students in developing hypothesis about the information they gather. For example, a student studying a chemical reaction might discern the components and even hypothesize as to the relations between these components; however, the investigation cannot go much further. Needed are tools that provide continuity between observation and model-building, furnishing the ‘missing link’ between data-gathering and the construction of theories using computational representations. That is, to make the study of these phenomena accessible to all students, we need new technological tools that foreground and unveil the deep structures. This poster will focus on *‘hybrid modeling,’* a framework for ‘trans-media’ scientific exploration and modeling which merges two types of educational technologies commonly used (separately) in schools. The first kind is robotics and sensing (Martin, 2000; Resnick, 2000) that uses computer-controlled electronic sensors and actuators to enable a wide range of experimental activities in the real world. The second technology is multi-agent modeling-and-simulation environments, such as NetLogo (Wilensky, 1999), where learners model complex natural phenomena by embedding very simple behaviors into elementary computational agents (Wilensky & Resnick, 1995). We have linked the two technologies – the “real” and the “virtual” so as both to broaden the possibilities of *situated investigations* and ground computer modeling with real-world validation.

Typically, students build a *computer model* of a particular scientific phenomenon, such as heat transfer (see Figure 1) or gas laws (see <u>Figure 2</u>), and a *physical device* equipped with electronic sensors. The models are then linked in real time through a low-cost, easily programmable analog-to-digital interface - the *GoGo Board* (Sipitakiat, Blikstein, & Cavallo, 2004). Students are able to run their computer model in tandem with the physical apparatus, comparing their outcomes, and debugging their model until it matches adequately the real-world data. We built various proof-of-concept systems for ‘hybrid’ explorations in heat transfer, gas laws, acid-based and oscillating reactions, and Materials Science. Our main goal, however, is to create a technological infrastructure to enable students to build their own systems.

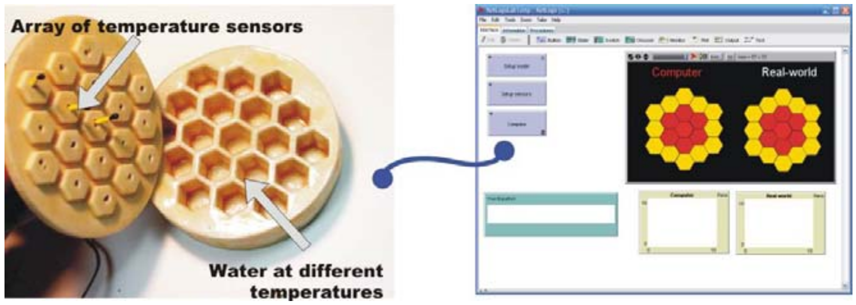

Figure 1. A ‘hybrid’ system for investigating heat transfer.

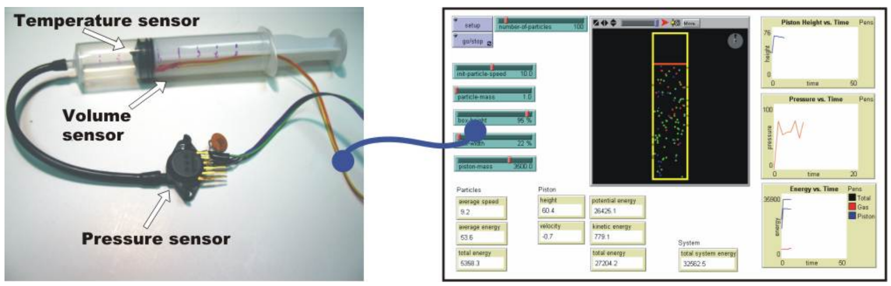

Figure 2. A ‘hybrid’ system for investigating pressure, temperature, and volume in a gas container.

In a pilot study, we compared artifacts generated by undergraduate and graduate students under two distinct conditions. In the first condition, students created multi-agent models *with no* sensors or robotics. In the second situation, another group of students built ‘hybrid’ models *with* sensors. All students built their models as an assignment in an ‘Educational Design’ course. Our data include students’ artifacts, field notes and transcriptions of interviews. Preliminary results suggest that students attended to phenomenal factors which they would otherwise have overlooked, such as energy loss, reversibility, and measuring error. In turn, students “complexified” their computer models so as to include these factors. This interactive poster will exhibit the platform in action, present student artifacts, and summarize our findings and conclusions.

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