Virtual Worlds, Cognitive Maps

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This presentation explores the power of simulation building as a constructivist learning activity and develops an agenda for the pursuit of research in this area.

Our project evolved out of repeated observations that multimedia students, working as programmers and designers on agent-based computer simulations of complex adaptive systems, often became enthusiastic and insightful about the content of the simulations. We have come to believe that the creation of an interactive simulation is a highly effective way to learn challenging concepts that require new habits of mind. We are recommending the *construction* rather than the *use* of a simulation to achieve our objectives, because the creation of a successful simulation requires the learner to acquire both a cohesive overview of the material and an intimate understanding of its details. It is also our contention that learning to design and implement simulations is an appropriate educational objective in its own right.

Simulation building as an educational goal

Besides its role in education and training, simulation is an important tool for analysis and research in the sciences, economics, and business. Students are increasingly likely to encounter and use simulation as a problem-solving strategy in their careers. We think that students should gain familiarity with methodologies for the design and construction of simulations as part of their education.

Figure 1. "Ants" bring "food" back to their home base. Aaron Cloutier and Christopher Meier built this online multiuser simulation.

Learning how to design a simulation is similar conceptually to learning how to design a scientific experiment. First, students repeat successful experiments to extend their knowledge of science and its methodology. Subsequent learning experiences challenge students to acquire new strategies in order to design effective experiments. Advanced students identify interesting problems on their own and invent new strategies for advancing their knowledge. Students learning about simulations would benefit from a similar sequence.

Designing simulations in an area under study teaches students to structure their knowledge of the topic in very much the same manner as does writing a term paper. The task of implementing their design tests and reinforces their mastery of the content. Through this process, they not only learn more about the topic, but also acquire a methodology for continued investigation.

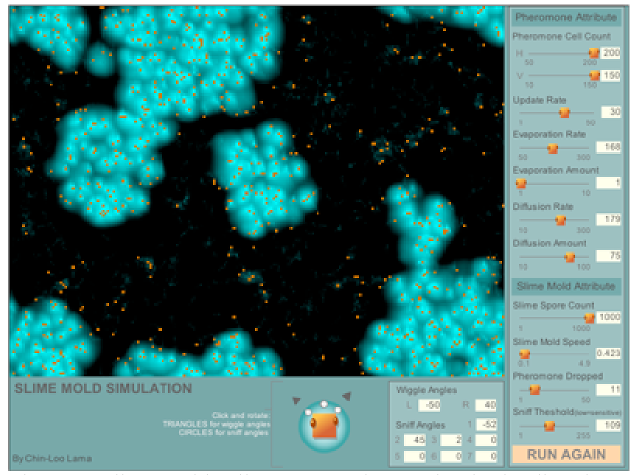

Figure 2. Slime mold cells aggregate by moving in the direction of a pheromone gradient. Simulation by Chin-Loo Lama.

The use of existing simulations is often an effective learning strategy, but is typically constrained and directed. Building simulations in a learning community requires students to make decisions about the inclusion and exclusion of various details and components and encourages them to define and defend their own cognitive structure for the domain. In writing a paper, misunderstandings or poorly formed ideas will go uncorrected until a sharp reader provides feedback, but if work done on a simulation is marred by incorrect or poorly understood concepts, errors will usually be self-evident. The simulation provides timely, automatic feedback to the learner.

By their nature, simulations provide an active learning experience, but there is a continuum of this experience, ranging from the structured exploration of existing simulations to the construction of a custom simulation to explore new ideas. Different learning populations and content areas will have different requirements, but most students will benefit from a degree of scaffolding and support, and to this end, we propose the development of toolkits for building simulations.

Scaffolding with toolsets

Students created the simulations included with this presentation during a single ten-week course, but their rich experience was enabled by prerequisite course work in multimedia programming. It is our goal to provide a similar experience of simulation building to a wider audience, including novice programmers. The work of Mitchell Resnick and Uri Wilensky and the learning communities that have evolved around StarLogo and NetLogo has inspired and informed many of our efforts. We experimented with their software in our classes with good success, but the intensity of our experience with the 3D class has caused us to take a new tack. Nearly all of our students play video games, and we feel we have been able to leverage that interest by incorporating high production values and realism into our simulations. Good simulations, like good video games, follow world rules and are self-consistent, but the best simulations and games also play well and look great. Our students recognize these qualities and work hard to attain them.

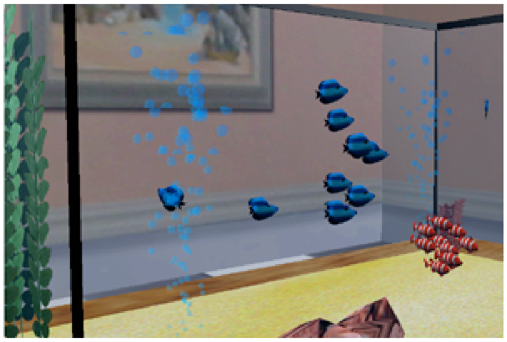

Figure 3. Two separate schools of fish exhibit different behavior based on user-controlled inputs. Simulation designed and programmed by Chris Cascioli.

Future directions

We are currently in the process of building toolkits to allow novice programmers to assemble simulations with production values similar to those created in our classes. The four basic areas in which we plan to offer support are 3D modeling and navigation, camera controls and interaction, the design and implementation of agents, and multi-user communication. Our present efforts center on self-organizing systems and principles of emergence, but eventually we intend to create modules with broader generality. This summer we have content experts from psychology and biology working with our students to create simulation kits to support student research in both of these areas.

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