Posterboards or Java Applets?

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Abstract: In project-oriented courses, students often research a topic guided by a number of relevant questions and then collect and present their findings in the form of a report or a posterboard. Recently, and with various degrees of success, the web is used as an information resource. Teachers evaluating the resulting artifacts experience difficulty in differentiating between students actual understanding of the topic area and prolific copying and pasting approaches. In the context of a social studies class, we explored the idea of having students build interactive web-based simulations instead of posterboards as means to gain a deeper understanding of complex issues. To build a running simulation students cannot simply paste existing pieces together. Instead, they are actively engaged students by being forced to map one kind of representation onto another. At the same time, the notion of simulation is not a trivial one. Fully appreciating the value of simulations requires time and building one requires additional effort by the students. This paper reports on the use of the AgentSheets environment in having students with no programming experience build interactive simulations that they could share through the web as part of a non-technology centered social studies course on protest and reform.

1. Introduction

Attempts to incorporate computer technology into the classroom typically focus on using educational systems in math and science classes. Systems such as LOGO [Papert 1980] and Algebra or Geometry Tutors [Anderson et al. 1995; Koedinger & Anderson 1997] have been used in math classes, whereas simulation systems such as AgentSheets [Rader et al. 1998] and Cocoa/KidSim [Gilmore et al. 1995; Rader et al. 1997] have been used in science classes. In the social studies realm, the technologies being used are word processors and the web. Teachers type up assignments for students or find information and curricula on the web. Students surf the web to research topics of interest, use word processors to type papers or posterboard material. It is not clear what the students gain by creating posterboards, as they admit to becoming experts in cutting and pasting information from encyclopedias, books or web pages without actually learning what they were writing about.

While at first glance math and science seem more appropriate applications of technology in schools, using end-user programmable simulations in social science classes can support and enhance the learning experience. The combination of social studies content with simulation technology can be an enticing and effective as well as an alternative way for students to explore topics relevant to the class. Epstein and Axtell [Epstein & Axtell 1996] observe that "the social sciences are hard [..] because certain kinds of controlled experimentation are hard. In particular, it is difficult to test hypotheses concerning the relationship of individual behaviors to macroscopic regularities [..]. How does the heterogeneous microworld of individual behaviors generate the global macroscopic regularities of the society?". Simulations are good candidates for exploring social phenomena in ways that are not possible to experiment in the real world. Social scientists and Distributed Artificial Intelligence researchers use a variety of agent-based software for modeling social phenomena, such as Epstein's and Axtell's Sugarscape, but these systems are rarely, if at all, used in K-12 social studies classrooms. Whereas simulation technologies have been used in math and science classes with a number of success stories [Rader, et al. 1998], the same is not true for social studies classes, because social processes are usually more complex to simulate than physical phenomena and social studies teachers do not see a connection between their subject and simulation technology.

This paper discusses the application of AgentSheets, an environment that allows end-users to create SimCity™-like interactive simulations, in a high school history class whose teacher did see the connection of the subject with simulation technology.

2. Simulations as Story Telling

Gradually, the notion of simulation is becoming a new form of communication and learning. As Turkle [Turkle 1995] observes, we are moving from a culture of calculation toward a culture of simulation. “The lessons of computing today have little to do with calculation; instead they concern simulation, navigation, and interaction”. Software designers want to create environments to explore, instead of rules to learn. There are different kinds of simulations, however:

- ***Batch Simulations:*** a set of input parameters are provided, the simulation is run, and an output is produced. Typically, this kind of simulation is created by experts and is used by its creators to run experiments. Example: complex weather models.
- ***Interactive Simulations:*** the simulation is run and the user can interactively change the parameters or the environment of the simulation. Typically, this kind of simulation is created by end-users and is used as a means of communication. Example: SimCity™.

While we do not dismiss the former category of simulations, when we use the term simulation in this paper, we refer to the latter category. Interactive simulations are places to try out alternatives, "to escape from planning into the world of 'What if?'". As such, they support the notion of bricolage [Repenning & Ioannidou 1997], which is described by Papert as an organizational style that is negotiational rather than planned in advance. Such is, Paper claims, the intellectual style in which children program in Logo [Papert 1980; Papert & Harel 1993]. Moreover, interactive simulations can be used not only to model processes, natural or social, but also as a means for telling a story or communicate ideas.

2.1. AgentSheets: a Tool for Making Interactive Stories

AgentSheets [Repenning et al. 1998; Repenning & Sumner 1995] is an environment that empowers casual computer users with no formal programming training to build and publish web-based interactive simulations and interactive stories. The AgentSheets system serves as a *behavior processor* [Repenning & Ioannidou 1997] combining web page authoring, end-user programmable agents and spreadsheets technology. Similarly to the way a word processor allows end-users to manipulate static documents on a high level, a behavior processor enables end-users to manipulate interactive content such as simulations and animations. Static documents are typically captured by word processors in a document description languages such as Postscript. As a behavior processor AgentSheets uses the Java programming language to capture the interactive nature of simulation content in a format that can be embedded into web pages.

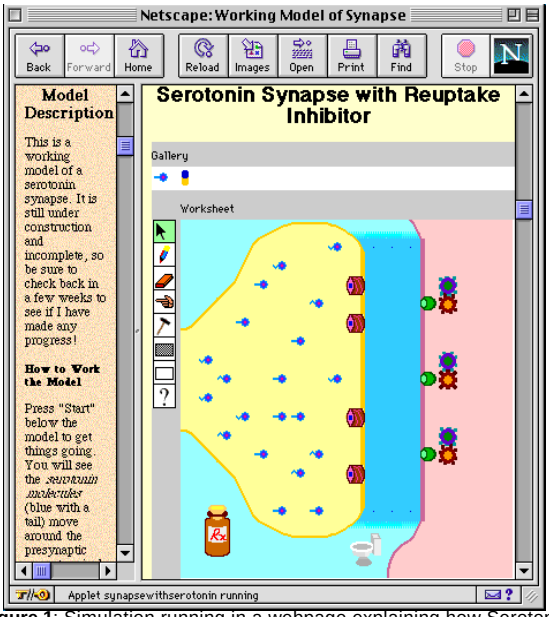

Figure 1: Simulation running in a webpage explaining how Serotonin works in the Synapse and how Antidepressants affect the system.

Agent	Name	Description
	Serotonin Molecule	Moves in Presynaptic Nerve Terminal and is released into Synaptic Space.
	Reuptake Inhibitor	Forcibly pumps Serotonin back to Presynaptic Nerve Terminal.
	Prozac	Binds to Reuptake Inhibitors and blocks their ability to reuptake Serotonin.
	Serotonin Receptors	Activates Intracellular Machinery when Serotonin binds to it.
	Intracellular Machinery	Stimulates excitement and happiness.
	Medicine Bottle	Releases Prozac tablets into Synaptic Space

Table 1: Agent descriptions for the Serotonin Synapse Simulation.

The AgentSheets systems has been used to create a large number of simulations, and games in a variety of disciplines including computer science, environmental design, fine art, robotics, music, and biology by users ranging from elementary school kids to NASA scientists. A psychiatrist who created a Prozac simulation [Figure 1] is an example of an end-user building an AgentSheets simulations to communicate the works of the serotonin synapse in the brain and the effects of Prozac to his patients. A suite of agents [Table 1] was created for this simulation by specifying their look and their behavior using the Visual AgenTalk language (VAT) employed by the AgentSheets system. Figure 2 illustrates two rules from the behavior of the Serotonin molecule defining animation and interaction with membranes. Using the Ristretto™ agent-to-java-byte-code generator, the entire simulation was turned into a Java applet and was included in webpages. The applet can be accessed at http://www.csn.net/~wphillip/Synapse_applet/synapse.html.

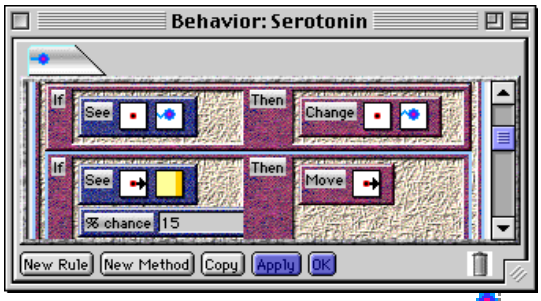

Figure 2: Part of the serotonin behavior which specifies that if the serotonin looks like , it will change to , or with 15% chance if the serotonin sees a membrane to its right, it will move to the right.

Instead of only using the text on his webpage or handouts with information on antidepressants, Dr. Phillips uses the simulation he created as a means of telling a story to his patients: the story of how the serotonin behaves in the synapse and how antidepressants, such as Prozac, affect the system. By the same token, a simulation in a social studies classroom can convey a story and communicate ideas in ways that go beyond the presentation of the same idea on a posterboard.

3. The New Vista experience

It is usually perceived that math and science classes are the most appropriate for introducing technology in general and simulation technology in particular. The fact that social phenomena are usually more complex and therefore more difficult to simulate than physical phenomena may be part of the explanation. Interested in using simulations in his "Protest and Reform" history class, John Zola, a teacher at New Vista High School worked with researchers from the Center for LifeLong Learning and Design (L^3D) at the University of Colorado. In his class, students had the opportunity to study protest movements throughout U.S. history (e.g. the Civil Rights movement and the anti-Vietnam war movement) and to learn about theories of protest and social change.

3.1. Getting Projects Started: Experiences with the Entire Class

To familiarize students with the AgentSheets system, the whole class participated in activities the teacher and the researchers prepared. In one of them, the students read Schelling's "On the ecology of micromotives" [Schelling 1971] and were engaged in the activity the author suggests (placing red and blue poker chips on a grid according to specified rules) to illustrate the concept of micromotives causing macrophenomena. Then, the L^3D researchers introduced the Segregation simulation, the AgentSheets version of Shelling's game. The students were encouraged to experiment with changing the populations of red and blue people, the world they lived in and the rules that governed their behavior. To give students a better sense of the applicability of the technology to the content of the class, we exposed them to a variety of AgentSheets simulations completely unrelated to the class. These included music simulations, games such as Packman, and bridge building simulations. Finally, we created a modest protest simulation to illustrate principles of human behavior as observed in actual protest marches and had the students experiment with it.

3.2. Final Projects Experiences: Beyond Posterboards

Following the initial efforts to create a content background and familiarity with the technology, students had the choice to develop a computer simulation, create a posterboard or write a paper as a final project for the course. Two groups of young women chose the simulation option. Susana, Claire and Maya researched and created a simulation based on the Cesar Chavez led Grape Boycotts and the United Farm Workers struggle, while Steph and Mara, inspired from the last class activity, created a simulation on what happens when a large-scale peaceful protest becomes violent and encounters police resistance. Each group not only developed a simulation, but also crafted web pages to display their work and extend the reach of their research, which in a way can be thought of as creating web-based posterboards enhanced with Java applets. These students were by no means technology experts. As a matter of fact, they were intimidated by technology.

> **Susana**: "I have always been one to fight with the computer. I wouldn't have the slightest clue where to begin and I'm not sure I'd want to".
>
> **Claire**: "I have a hard time with technology. I just don't get it! I wish I did, but I barely know how to turn a computer on".

The following sections describe these projects and the process by which they were created. Despite the initial apprehension with technology, the projects exceeded the students' expectations on the excitement they experienced and the learning that occurred in the process, the quality of the result, and the appraisal their work has gotten since its publication on the web.

3.2.1. The Grape Boycott Project

The first group selected the topic of the California Grape Boycott in the context of the Chicano/a, Latino/a Civil Rights movement for various reasons. Claire was "curious to see a simulation much like our world play out",

whereas Susana and Maya coming from Hispanic-descent families were personally interested in the topic. Their plan was to build a webpage with a simple boycott simulation applet and links to related web sites to serve as a virtual library on the subject. Before building the simulation, the students realized that they needed to find out more about the history of the Boycott and the United Farm Workers movement. By doing some initial research in the library and on the web, they learned the basic historical facts and found relevant information in webpages they would include in their own and started creating the simulation.

Figure 3: Bird's Eye view of the Boycott: workers pick grapes in fields, while Chavez influences consumers not to buy grapes.

Agent	Name	Description
	Mexicans, Filipinos	Pick grapes until they get angry for the way they are treated by the farmers, go on strike, and get replaced by Braceros.
	Domestic	Picks grapes, does not get angry as he is not treated badly by farmers.
	Braceros	Works under any conditions.
	Grapes	Appear in the market when the workers pick them. When the boycott begins, they stay in the market and go sour.
	Farmer	Stands in the fields and yells "Work!".
	Cesar Chavez	Moves around town and influences consumers to boycott grapes.
	Consumers	Move around town and buy grapes at the market. Some more easily influenced by Cesar Chavez, others less. As level of influence goes up, turn darker shades of red. This simulates the gradual processes of social change and political activism.
	Representative	Moves around in the fields and influences the workers to go on strike.

Table 2: Agent descriptions for the Grape Boycott simulation.

At first they were really reluctant to do anything with the computer, but as the got into the simulation, the students felt more comfortable with the technology. We showed them the basics of AgentSheets (how to create a new project, how to create the depiction and the behavior of an agent) and they started their simulation.

Figure 4: The Boycott project web page includes (1) descriptions of the agents, (2) historical background and related links, and (3) the Boycott Simulation applet.

Presenting a complex social phenomenon such as the Grape Boycott without making the simulation overwhelmingly complex is challenging. Deciding what would be a good representative set of events that could be simulated became crucial. The teacher played an instrumental role by helping students decide what was important to convey in the simulation. He also helped them divide the workload among the group. Claire and Susana continued working on the simulation which represented individual people such as workers picking grapes, farmers that own the grape fields, consumers buying the grapes at the town's market, and Cesar Chavez who influences the consumers to participate in the boycott [Table 2]. The purpose of the simulation as to illustrate the relationships between all the people involved in the boycott: farmers, workers, consumers and

worker organizers. At the same time, Maya worked on the webpages [Figure 4] with the historical information and the related links they had gathered. This task was critical as it was providing the link between the course content and the technology used.

The process of building and observing the simulation led to new questions. When they programmed their workers to get angry and refuse to work, the students started getting confused. What really happened? How could there be grapes in the market when the workers were on strike? To answer these questions, they went back to the historical sources they had found. They learned that as the Mexican and Filipino workers went on strike, illegal immigrant workers (Braceros) were hired. To reflect this, the students added this new feature in their simulation. The final version project is accessible on the web at http://www.cs.colorado.edu/~l3d/systems/agentsheets/New-Vista/Boycott-Project.html.

3.2.2. The Protest Project

The second group decided to do a simulation based on the principles of protests [Figure 5]. Steph and Mara seemed intrigued about the possibility of creating a simulation for their final project, but were unclear about what that might entail or what it might be about. The teacher proposed that they explore the possibility of simulating what happens in peaceful protest marches that turn violent and involve police confrontations. As he discussed his experiences in such marches and the historical examples of them, they grew increasingly excited about the topic and the potential for the simulation. In this case, it really was the teacher sparking an interest, unlike the Boycott simulation where the students came to the project with already an interest in the topic .

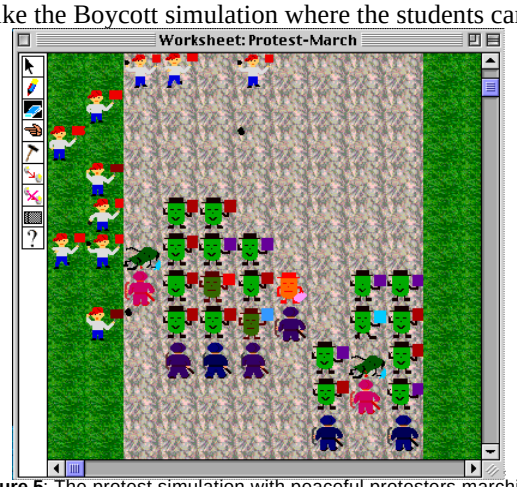

Figure 5: The protest simulation with peaceful protesters marching, violent protesters hitting the police and the police reacting to them

Agent	Name	Description
	Peaceful Protester	Marches peacefully and moves his sign. Never gets violent
	Violent Protester	Marches and moves his sign. His aggression level goes up when he gets hit by rocks and depending on how angry he gets, he starts hitting the police officer in front of him with his sign.
	Counter-Protester	Stands along the path of the march and provokes the protesters and the police by throwing rocks.
	Police Officer	Reacts to the protesters depending on his aggression levels:

Table 3: Agent descriptions for the Protest Simulation.

After some initial research in the library and on the web to find information on protests, the students chose to do a protest march simulation on the legalization of marijuana. They thought it would be interesting to create their own protest as opposed to replicating one from history. They chose this particular topic because they wanted to get a point across, voice their opinion, and form their own protest supporting what they believed in.

When they had all the individual behaviors for their agents, the students realized that they had to understand how the system works as a whole. Understanding each of the agents in isolation was not enough. They had to understand how they interacted with each other and how each agent's actions had an effect on another's behavior in a protest march. Having to program those interactions into the simulation was the point when they learned most about how protests work. For example, they had to understand that the police officers, who have the responsibility to keep things under control, can be violent when things start to get out of hand as their roles become confused: on one hand, they are responsible for protecting the right to assemble but on the other hand they want to protect themselves from attack. To show how situations can escalate and get out of hand, the students programmed an incremental behavior for their police officers. When the police officers are not angry, they retreat when they are faced with many protesters, advance and push protesters back if they get angry, and hit them if they are really angry. They also get colorized in shades of red as their aggression goes up.

As in the case of the Boycott Project, the teacher urged the students to divide the work, with Steph working on the simulation and Mara creating the webpages. The resulting project is accessible on the web at http://www.cs.colorado.edu/~l3d/systems/agentsheets/New-Vista/Protest-Project.html.

4. Discussions

Interesting issues arose in our New Vista experiences. Some of them concerned issues such as breadth versus depth of learning experiences and students' mindsets on simulations and how they affect their experiences. The following sections discuss these issues in some detail.

4.1. Breadth Versus Depth

Creating a posterboard may be an opportunity to explore a topic in depth. However, it does not necessarily happens when students create them. Students admit to becoming experts in cutting and pasting information from encyclopedias, books or web pages without actually learning the material they are writing about. When building simulations, on the other hand, students do not have the option of mindless cutting and pasting. To create a good and accurate simulation the students needed to develop a deep understanding of the subject they were simulating. In addition, since they were including their simulation in webpages, a variety of skills was demonstrated: programming and artistic abilities for creating the simulation, writing, and web authoring for publishing the simulation on the web and providing context for the simulation. Typically, when groups of students are engaged in AgentSheets-based activities not every student gets the same exposure to all facets entailed in creating and publishing a simulation on the web. Different areas of expertise develop within the group. People that do not view themselves as artistic may not want to take on the task of drawing the looks of the agents or their animation frames, but they become expert VAT programmers. Conversely, people that do not feel comfortable with the idea of programming but are good at drawing or writing may choose to create the icons or write the accompanying material for the web pages. Yet, all have to interact in building the final product.

In the Boycott project the students had to learn the history behind the Grape Boycott in order to create their simulation. Moreover, they needed to have a level of understanding of this historical content well beyond that of regular type projects (e.g. a posterboard). The same held true with the Protest project. Creating the behaviors of the individual agents was one thing, but programming the interactions among the agents required a deeper understanding of how protests worked in the past and knowledge of human nature under those circumstances.

AgentSheets-based activities can encompass the best of both worlds, breadth and depth, within an authentic and self-directed setting. To create an AgentSheets simulation, one needs to deeply understand the underlying principles of the simulation topic. One cannot just memorize a formula, a relationship or some other fact. A lot of thought needs to be put into understanding where exactly that formula is going to be applied or how the relationship is going to work, between what agents and under what circumstances. When the activity is not limited to creating a simulation, but also publishing it for a web audience, the students get the benefits of breadth. These include domain knowledge, constructing simulations, web authoring, and writing, exposure to a variety of ideas and the ability to make knowledgeable choices on which interests to pursue, and the ability to make connections in many different disciplines and enjoy the benefits of all of them [Collins 1996].

4.1.2. Mindsets: Students' Perceived Value of Simulation

The notion of simulation is not a trivial one and therefore to fully appreciate the value of simulations requires time. For the activity around Shelling's article, we expected students to be excited by the computerized version of the game, which was faster than moving around poker chips and more controllable by being able to change the rules and see the result immediately. However, we did not anticipate the effect that a slow-running (and often crashing) simulation on old equipment would have both on students' motivation and on the outcome of the activity. Nor did we know anything about the mindsets of the students and how they perceived what a simulation is and what its value is.

Students reacted differently and expressed preferences towards the physical or the virtual version.

Nico: "I learned a lot more from [the board game] because it was actually me doing all the thinking and not the computer".

Joanna: "I liked the fact that I got to sit back and watch these fake communities integrate and segregate".

Max: "I did find the computer version slightly more entertaining. This was because you could tell it what to do and hopefully it would do it. The benefits of the computer program was it is much quicker than doing this by hand. We were able to change the environment, population and what the preferences were relatively quickly. It was more amusing to watch the computer characters move about than to place checkers on a board".

Jessica: "I thought that it was more interesting and more enjoyable than simply playing out the simulation on the checker board. This was all because you did not have to think so much about the rules, about who was unhappy and where they needed to move. The computer took care of all this so I was able to apply the situation to real life better".

We realized that students have different perceptions of what simulations are and what they are good for. Some students think of computer simulations as TV shows, where they can "sit back" and watch it play out, as is appropriate for batch simulations. Others perceive simulations as opportunities to explore alternatives that are time-consuming to perform in the physical world or even impossible. Others viewed the computerized simulation as taking care of the tedious details and therefore freed their minds to think about the concepts the simulation was trying to convey. With the interactive simulations built with AgentSheets, we are aiming at a user participation level that goes beyond the TV-attitude towards the computer [Repenning & Sumner 1994].

The five students who created the Boycott and Protest projects, had different perspectives on the subject, after having built simulations themselves and learned from the process.

Claire: "I didn't know anything about the boycott before. Having to apply it to the technology made me get into it more and understand it fully so that I could have it come out correct."

John: "More so or differently so than if you had created a posterboard?"

Susana: "You had to know more because you couldn't leave out things. So if you didn't know everything you couldn't do it."

Steph: "It's not like you can copy it out of an encyclopedia and put it on the posterboard".

Mara: "It wasn't just boring writing stuff down; we got to interact with what we were doing".
Steph: "[making the protest simulation] totally made you apply what you know towards like what you're doing!"
Susana: "I took this class just for history; I didn't know it was gonna be anything with computers, but now that I did the whole computer thing, it's changing my daily life cause I used to hate computers and now I don't."

People using and building simulations acquire different perspectives simulations. No matter how interactive its creator makes a simulation, there is always the danger of using it TV-style. The process of building a simulation, however, forces users to go beyond this and really transform information into knowledge in the process of mapping that information onto behaving agents in a simulation. When creating a posterboard this mapping does not necessarily happen, as students can just copy and paste the information without having to process it and learn from it.

5. Conclusions

Traditional ways of exhibiting learning, such as posterboards, are sometimes not effective as students have mastered the art of copying and pasting information from books or the web. Students can go beyond this by not only posting their posterboards on the web, but more importantly enriching them with interactive simulation applets. Building simulations forces students to do an in-depth examination of their topic. When John Zola will teach the same class again next year, we want to explore how we can make the success we had with the five girls systemic. In doing that, we want to explore the experience for the class as a whole can be improved.

John Zola: "One of the things that was hardest for me in this process was trying to keep you guys interested in history, but also to provide time and space to do the technology and it always felt that one was sacrificed to the other, that you guys sort of got angry sometimes when the history went by the boards. Clearly we didn't necessarily go about it the right way, but trying to build the technology base and interest, I remember you guys complaining 'why aren't we learning history in this?' So there was a really interesting tension."

Tying history with simulation technology was not easy. Now that the social simulations and webpages the five girls created exist, they would be appealing demonstrations to start off with, because they make a more explicit connection between the social studies the students think they will learn in this class and the technology we want to bring into it.

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