

## **Teaching a Conventional Class (Global Studies) In An Unconventional Manner Using STELLA**

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### **Introduction**

Ever since being introduced to STELLA, I have used it in my science classroom to teach a unit on ecological issues in my Earth Science classes. In doing this, I meet my “stated” goal of teaching the students how the system we are investigating works. I also meet my hidden goal of getting the students to “ask the better question”<sup>1</sup>, to really see what the key pieces or leverage points of the system are and how they have large effects on the system as a whole.

As a core team instructor during the CC-STADUS/CC-SUSTAIN Summer Institute, I (and the other team members) began to notice that, while the science models being built by the science trainees as part of their work were interesting, the social science trainees models were by far more interesting and loaded with potential for student inquiry. Science models, with the exception of those designed for biology, were problem-focused, while social science models tended to be broader in scope and impact.

After some discussions with our building administrators, some work “away from it all” at the Waters Center for System Dynamics in Vermont, and funding for a co-teacher for the class (me) from the Waters Foundation, Megs Patton and I managed to develop a course in Science, Technology, Society and World Issues. This is an Honors course in global studies, covering the typical subjects of a global studies course (political, economic, religious, and social systems of the U.S. and of countries around the world) and adding a twist: the students build, use, and refer to simple STELLA models of the system being studied. The assumption is that the model will direct student attention to, and promote further research on, the critical points of the system being studied. We’re still in our first year of teaching this course, but the results are beyond our most optimistic expectation.

### **A “Brief” Description of the Course: What We Did**

For this course the students were given a notebook in which to write their musings, research, actual assignments, tests, and STELLA doodles. One of the key features of this course, unlike a “normal” global studies course, is its open-endedness: other than the first quarter (8 weeks), we were in no rush to get through any “vital” subjects, so we were able to devote as much time as necessary to each subject to cover it adequately (in our opinion, not our student’s opinions). This

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<sup>1</sup>British Petroleum Is Not Jackson Middle School: Different Best Modeling Practices For Different Environments, Tim Joy and Ron Zaraza, 16th International Conference of The System Dynamics Society Proceedings, 1998.

very open-endedness, frowned upon in most schools, is vital, as it allows adequate time for student directed research and investigation. All of the models produced by the students are expected to work except the most complex (the revolution models) since these models would take a year, or more, to develop, and we do not have that much time.

These are the key course components for our first year:

#### First Quarter

- Four weeks of instruction in the basics of STELLA. Cover the differences between *stocks*, *flows*, *converters*, and *connectors* and explore the behaviors of linear, exponential, and quadratic model structures and their graphs.
- Play the Fishbanks game. Profit-oriented students such as ours will wipe out all of the fish by turn five or six.
- Discuss what went wrong and what should be done to save the fish. The students made many suggestions here, ranging from taxation and permits, to fish farming.
- Build a STELLA model of the Fishbanks game as a class.
- Examine the model, checking to see if the class solutions would actually work by modifying the model to test them. Many of the solutions proposed before constructing the model were abandoned immediately by the students without testing because they could see that they were influencing a part of the model that had no impact on the number of ships or fish caught. Many new suggestions were made. The eventual “best” solution decided upon by the class was fish farming, since everyone “should have the right to make a profit”. However, this led to the new question of how this would effect the genetic diversity in the fish species. This idea was explored later by a student group as a potential ecological disaster issue.
- Assign daily model presentation dates to students. This is similar to “current events” assignments in many courses, with the added requirement that the student must choose a current event in which a system is prominent and present a sketch of a model (not a working model) that describes the system in question. After a five minute presentation of the issue and model by the student presenter for the day, the rest of the class would spend five to ten minutes in discussion on the issue and the model.
- Research and examination of other “ecological” disasters of student interest (constructing STELLA models of the systems affected). Many students chose to explore the effect on virulent non-native species such as kudzu in the U.S., rabbits in Australia and New Zealand, and rats in the Pacific Islands. Others chose to explore the spread of exotic diseases among the human population (Ebola, Dengue Fever). The models the students developed at this point exceeded our expectations. The level of complexity of the models of the issues that the students wanted to explore required some teacher assistance.
- Build a model of post collegiate life earnings, including standard of living requirements. Students had to do a lot of research here not only on the salary range of their chosen field of work, but on all of the costs associated with the lifestyle they expected to lead. This unit is very similar to an entire personal

finance course.

- As the students researched their intended lifestyles we took time out to watch and discuss a Food for thought film “Affluenza”. This film greatly disturbed the students who had never given their habits of consumption much thought.
- Discussion on “realism” of their completed models.

### Second Quarter

- Revolution: What is a revolution (brainstorming session)? The students decided that political and social revolutions are caused by unmet needs or perceived injustices and that technological revolutions were caused by rapid change in “the way things are done”.
- An brief overview of the French Revolution (students resist study of the American Revolution vigorously) through film and teacher presentations. In the brainstorming session on the probable causes of the French Revolution, the students identified social unrest (class warfare), the economy, the philosophical thought of the day (Voltaire, Locke and their compatriots), the recent success of the American Revolution, and the availability (or unavailability) of leaders.
- Group research projects in subject areas that were identified as being important in the brainstorming session.
- Groups presented their reports (and supporting models). Both the models and the reports were examined for “reasonableness” by their fellow students. The models here were not intended to be working models (more on this later). Lots of discussion.
- A reasonable model incorporating the separate student models was built from their group reports as a class project. The class discussions using the “big picture” model ended in concluding that the main cause of the revolution was economic. The money problems of the noble class caused them to sell off their estates to the growing middle class who, in turn, cut off the right to free pasture for the peasant class. This, along with poor crops and rising population drove food prices too high for the peasants, making them eager to rebel against the nobility.
- Brainstorming on other revolution topics. Individual students research, and modeling of a second topic of revolution (and written report with a presentation) – these topics were not restricted to political revolutions. Among the topics were the Information, Industrial, Agricultural, Green, Vietnamese, Russian (Communist), Russian (anti-Communist), Cuban, Iranian Revolutions, the Civil War (War Between the States), and the War of the Roses.
- Student models are examined for similarities. The students decided that most revolutions are triggered by economic events, usually involving the perceived lack of economic opportunity.
- Reflection and discussion on the similarities between shortfalls in student “standard of living” model and causes of revolution. At this point, a student brought and read an article on the growing disparity in the distribution of wealth in the U.S. This led to a discussion of whether or not a revolution can only be violent in a democratic society or if a revolution can be caused by voting for radical change.

### Third Quarter

- We examined the probable reasons for immigration to the U.S. (legal and illegal). Discussion, research assignments (based on the discussion) and model building. The students focused on quality of life and economic disparity (get rich quick) issues.
- Food for thought film: “El Norte”, a story of a brother and sister who illegally immigrate to the U.S. and their adventures here. This film caused a vigorous discussion and some independent (non teacher assigned) work on the differences in the perceptions of what constitutes poverty around the world.
- Reflection on how causes of immigration (conditions in U.S. vs elsewhere) relate to revolution. Once again, the students focused on the lack of economic opportunity.
- World Population growth research, discussion, and model building, followed by doing the same process for individual countries (all three “worlds” represented). The students were fascinated by the model behaviors for countries that show a declining population such as Italy.
- Population growth controls discussed, researched, and modeled, along with research and discussion on how the individual countries view their population growth. Some students questioned the sanity of the leaders of some high growth, low resource countries that see their high population growth as being beneficial to their country.
- Interactions between population and natural resources for various countries researched, modeled and discussed. Interactions between world population growth, world-wide levels of Greenhouse Gasses, resource distribution, and industrialization were also researched, modeled and discussed at this point.
- Food for thought film (and model): Mahenjo Daro, where the need for bricks was driven by population growth and led to de-forestation, which led to more destructive flooding, which led to the need for more bricks. . . . a classic self reinforcing growth curve. The students built a model of this situation.
- Agriculture and population interactions for various countries researched, modeled, and discussed. The models were used in discussions of dietary needs and whether these needs could be met world wide (eradicating famine).
- Food for thought film: “Soylent Green”, a future world where overpopulation and pollution have ruined the food supply, forcing us to “recycle” our dead into crackers for human consumption (we added some comic relief with a “Soylent Green” modeling assignment).

### Fourth Quarter

- Serendipity at this point: The Sierra Club “Immigration” vote! Discussion and modeling of the pro and con arguments. This was a fantastic opportunity at this time. Because of the modeling we had done with population growth and resource/food distribution, the discussion was highly animated and frequently punctuated by students going to the board to draw a model of their argument. The students decided that both world and U.S. population growth must stop (and possibly the populations must decline) to protect the environment and that the

anti-immigration argument would only result in a short term reduction in the growth of the destruction of the environment in the U.S. and not slow the destruction of the world environment.

- Case studies of countries in bad situations for different reasons (post revolution and economic): Cambodia/Kampuchea/Cambodia and Indonesia. Including research, discussion and models (again).
- Food for thought film: "The Killing Fields" and media articles, CNN and BBC reports on the Indonesian economy. The "secret agenda" item here: getting the students to think about what are the key considerations for running a country.
- Last three weeks: Introduce "Stratagem" game, its roles, and discuss how they may interrelate. Build a model of the game as a class, seeing if our discussion was on target. Play the game. Discuss how things went after play completed.
- Reflect one last time on how the things that we studied are connected.

This is the basic outline of the course, an intense year of learning. Throughout the course, our use of STELLA to model the situations we studied was the key to student learning. The rigor and precision imposed by model construction using STELLA gave the students a feel for what the proper relationships between things were in ways that loop diagrams cannot. For example, no models turning people into cars survived the scrutiny of the class even without help from the teachers. Units were preserved and cause-effect relationships were well thought-out. The discussions that resulted when using the models as a base for understanding rarely fell into the category of wishful hand-waving. When they did, the other students directed the discussions back to the realm of logical arguments rather quickly by pointing out that what the student was saying could not be supported by the model.

The immediate desire that the students had to add modifications to the models they built and were discussing in class, and their desire to explore the ideas that resulted from those discussions in even more depth, was both interesting and frustrating. It was interesting in that they were functioning as their own teachers, learning without our input, direction, or control. This was student directed learning at its best. It was frustrating in that these were missed opportunities for learning, since we had to cut these sessions off after a day or two in order to cover a minimum of material over the course of the school year. If they had been allowed to do everything they wanted, the class never would have gotten beyond the Revolution unit.

### **Plans For Next Year**

Overall the class has been highly successful. However, as with all first attempts, improvements can be made. The biggest change that will be made will be to place the revolution unit at the end of the year in the fourth quarter. The amount of time the students needed to spend doing research on their topics after learning STELLA caused their modeling skills to atrophy substantially, forcing us to use a week and a half to bring them back up to speed at the end of that unit when they had to build their revolution models.

Also, we will work on filling in a glaring hole in student research skills that we discovered early in the year. As the preliminary research on the French Revolution began, we discovered that our students did not know how to use the library or the Internet for basic research. Rather than take

the time to teach them how to do this (something we thought they should already know), we resorted to functioning as research assistants for the students. With three groups of five students each to a teacher, this was very exhausting. Next year, time will be taken at the beginning of the course to teach these skills, which should ease the burden on the teacher. Other than that, we wouldn't change a thing. The quality of the student work and discussions was a level above that of the typical accelerated Global Studies class at our school.

The student comments on the course at the semester break were also interesting. Several students complained that they signed up for a global studies course, not a science course. When pressed for details, we found that this was a reference to the STELLA modeling component of the class and to the "ecological" subjects covered early on. Later in the year, they admitted that they just did not see the connection between these subjects and global studies at the time (they do now). Also, some students complained that they seemed to be wasting time sitting around and doing nothing. These were students who did not have much experience in open-ended assignments and desired more direct teacher involvement in their learning. They learned to do without this. Near the end of the year, the student comments were quite positive, especially when looking over their notebooks: "I can't believe that I learned so much!"

Samples of student work will be posted for all to see at [www.teleport.com/~sguthrie/stswi.html](http://www.teleport.com/~sguthrie/stswi.html).