GLOBAL CHANGE EDUCATION

The Use of System Dynamics Concepts for Science and Policy Interface

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My primary research interest is in improving communication between atmospheric scientists on the one hand and the general public and policy makers on the other hand. Miscommunication is delaying the implementation of effective policy intended to mitigate global climate change caused by human intervention.

Solutions to the problem of global warming will have to be formulated by policy makers working cooperatively with scientific experts. This global problem will require global cooperation and solutions. If there is to be rational and effective policy regarding global warming, policy analysts and the public need to better understand the environment. Effective communication and education are paths to better use of scientific knowledge. A higher level of understanding can lead to better analysis and design of the best policies for reducing the rate of environmental change or adapting to it.

On November 30, 1995, the Intergovernmental Panel on Climate Change (IPCC) stated that the balance of evidence suggests that there is human influence on global climate caused mostly by fossil fuel use, land use change, and agriculture. (Science, Vol. 270, 12/8/95) This panel concluded that without action to reduce greenhouse gas emissions temperature change could cause widespread climatic disruption. The panel, a United Nations group of 2,500 scientists from around the world advises the parties to the 1992 treaty limiting greenhouse gas emissions. The fact that it could conclude that climate change was influenced by human activity and could cause climatic disruption demonstrates the overwhelming nature of the evidence, and the perceived pressure to address this problem.

The Science Policy Gap:

This gap is what we might call the lack of communication between experts in atmospheric science and non-experts. The terms expert and non-expert are vague and need definition in the context of this paper. When used here expert will mean researchers in atmospheric science. It will not mean policy experts in this field. It is specifically applied to those with formal training in atmospheric science. All others are viewed as non-experts in this context. It should be clear from this definition that the group of non-experts is quite large and there will be a broad and varied range of understanding within this group.

Experts in this field have been analyzing these connections for years but are unable to clearly explain how the global climate system works to either policy makers and/or the public. Policy makers have already been intervening by developing policies aimed at limiting greenhouse gas emissions. However policy makers desire a greater understanding or a more definitive answer about the essential parts of our atmospheric and ecological systems so that policies can be more effective and future research funding can be targeted to the specific areas.

With this in mind I have developed what I call a *Pocket Model* of the global environment. For details of this model see *A Pocket Model of Global Warming for Policy and Scientific Debate* by Bernstein, Richardson, and Stewart, the System Dynamics conference proceedings, 1994, Organizational Environments, p.8. This model is intended to be scientifically accurate yet small enough to be understood by people who are not modelers or atmospheric scientists.

The *Pocket Model* is intended to illustrate in a general and accurate way the basic structure and interactions which take place within the environmental system. This model will be used to teach a variety of audiences about global ecosystems. Participants should gain a more accurate understanding of existing scientific knowledge about global environmental systems. This knowledge should give these participants a more rational understanding of environmental mechanisms and an understanding of why we need to reduce emissions. It may give participants new insights into potential policies for reducing emissions.

Experiment:

The challenge is to develop a method for effectively communicating the basics of the *Pocket Model* so that participants will focus on the structure of the model and learn about the environmental system. The long term goal of this research is to narrow the communication gap between policy makers and experts. In order to do this information about how well an audience can learn from the model is required. The intent is to teach and develop presentation materials that are effective while keeping the audience interested.

The learning which takes place I would call model based learning but it is different than the way the term is commonly used in the system dynamics literature. Generally when we use the term model based learning the application is the learning laboratories used at MIT to train managers and explore the basic dynamics of management systems. In this case I am referring to a model which reflects the current understanding of the global ecosystems and the use of this model as a basis for teaching groups of people.

At this date I have taught two undergraduate classes in atmospheric science. Because I was interested in information about whether the students had learned from these lectures I gave pre and post treatment surveys.

This data was collected not to engage in educational research where I compare one type of treatment with another to find the most effective teaching method. I am interested in discovering if system dynamics concepts can be used in teaching atmospheric science and in what types of presentations are effective. This is as much a test of the materials I am developing as in testing the learning of the students.

The material taught to the class was not the *Pocket Model* but smaller models of the sub-systems or sectors. The *Pocket Model* contains a heat, water and carbon sector. The class models were individual models of the heat and carbon systems. This dividing up of the model was done to simplify the teaching process. What I had in mind was a stepping up to the larger *Pocket*

Model once the dynamics of the smaller models were understood. This method follows the logic of the urban dynamics models used by Alan Graham in Introduction to Urban Dynamics.

Other teaching materials were overhead transparencies of standard atmospheric science textbook diagrams, STELLA diagrams of the models, and diagrams of the individual stocks, flows, and feedback loops. The diagrams were of small parts of the model so I could explain piece by piece how the model worked and how this related to what was known about the earth ecosystems.

The next step were diagrams of the feedback loops illustrating how heat affects evaporation generating water vapor, which is a heat trapping gas. Water vapor also affects cloudiness which both traps and reflects heat. During class I had two overhead projectors available. On one I placed the standard atmospheric textbook diagrams of the heat system while on the other I placed the STELLA diagrams of the model. I traced the formal model feedback loops and showed the corresponding loops in the textbook diagram.

By questioning the class about the connections between variables and feedback loops I completed explanation of the models and moved on to simulation. I used this to illustrate different scenarios and more importantly to demonstrate how different parts of the system can control the strengths and weaknesses of the feedback effects. One dramatic illustration was increasing cloud albedo (reflectiveness) which almost completely eliminates all global warming. This same process was repeated with the carbon sector.

At the current time I have used these teaching methods on two classes of undergraduates. Both classes were very different both in the interests of the students and in the classroom setting. Between now and the conference I will arrange other presentations and analyze data on the results.

Future Research:

Communication of knowledge is an important part of the research process. To date there is a great need to improve the communication between the scientific experts in atmospheric science and both the general public and policy makers. The reason for this is not due to any lack of skills on either side. The science gap is slowing the ability of policy makers to develop effective policy for the mitigation of global warming gases.

The next step in my research agenda is to complete development on a teaching and presentation techniques which explain the Pocket Model as clearly and concisely as possible. What follows is the bringing together of both policy making experts and atmospheric science experts to discuss the Pocket Model. This will lead to an informed discussion between these two groups. The intent is to create an environment where these two groups can communicate to each other effectively.