Using Models in Geoscience

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My geoscience career started over 30 years ago in solid earth geophysics, has touched on physical oceanography, and finally settled into atmospheric and climate change science. Much of my career has focused on science education; primarily teaching undergraduate physics and meteorology, and courses related to environmental modeling and Earth's climate.

Over the years my philosophy on science education has been highly influence by research in science education. Both the physics education and geoscience education research communities have influenced my approach to student learning. Student interest and satisfaction with the learning experience is always a top priority. As with most educators, sometimes we hit the sweet spot on this and sometimes not, but we always strive to get our students excited about the topic at hand. Another key element is the need to interactively engage students in a hands-on minds-on experience. Early in my teaching career I was introduced to the value of using computer simulation models to create active learning and inquiry base learning experiences for students. Although these sorts of activities are clearly not the only valuable interactive learning environments for students, they do appeal to my teaching style since much of my professional climate change research has been based on computer simulation models.

With this in mind, one method that I emphasize in my courses is how scientists use models to help them understand a system's past, present, and possible future behavior. One example student activity is a modeling activity designed to help students better understand the CO_2 problem. There first goal is to use a very user friendly online carbon cycle model (based on IPCC Bern Model) to estimate the carbon emissions over the past 50 years by obtaining a good fit between model and observations. To obtain good agreement between the model and observations of atmospheric CO_2 they adjust 3 parameters: 1) the initial 1960s CO_2 concentration; 2) the initial 1960 carbon emissions; and 3) the emission growth rate in percent per year. After this, they use their fit to explore possible atmospheric CO2 levels into the future based on different assumed emission scenarios such as: continue our present growth rate into the near future; accelerate this growth; or cut emissions growth rate. They also use the model to determine what cuts are required to keep CO_2 from exceeding some level like 450 ppm. Most students do a good job with this activity, are interested, and I hope are better prepared to critically read articles in popular publications related to this topic. It is often difficult to assess the lifelong impact of a particular learning experience since everyone assimilates information differently. The activity can be found at: http://www.atmosedu.com/physlets/GlobalPollution/CO2ModelAss2011.pdf .

In addition to learning about the strengths and limitations of models, my students are also introduced to key aspects of systems thinking while exploring different systems. It can be argued that a basic understanding of systems thinking should be included as a core learning objective for undergraduate colleges and universities.

Simulation environments created with computer simulation models are also easily transformed into a Game, either a solitaire game or a multiplayer game. My experience with using games for learning is limited but I have made several attempts, one of which is "The Energy Balance Game" at

http://www.atmosedu.com/Geol390/physlets/GEBM/EBMGame.htm . I intend to explore the use of model-based games for student learning more in the future.

Over the past two years I have become increasingly involved in online instruction. Computer simulation and modeling environments are ideally suited for this mode of instruction. I've found that the instructions for online assignments must be very clear and detailed to avoid student confusion and frustration, and if they are not clear students are very quick to provide feedback. This extra demand for quality and continued student feedback has helped me greatly improve all of my assignments whether for online courses or face to face courses.