Strategies for Teaching Modeling to Students

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Strategies for Teaching Modeling to Students

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Models are powerful tools for under-standing systems and solving ecological problems, but they overwhelm many students when they are first presented in life science courses. Models are often perceived as irrelevant, mathematically complex, or too abstract. Yet students need to be engaged in creating and using models—models are an integral part of the biological sciences. How can faculty help students understand models, recognize their relevance to biology, and develop an interest in using them?

Holly Ewing, in the Environmental Studies Program at Bates College, is committed to finding ways to convey the power and excitement of models. Her undergraduate students first create simple, conceptual box-and-arrow diagrams of familiar systems. "We start with the food system at the college," she says, "because it is familiar to the students and relevant to the course objective of understanding material and energy flow in the environment." She also challenges her class to think critically about the scientific models they encounter every day, such as the weather forecast, as well as those used to make policy decisions. "I want my students to understand that many decisions are made based on models, and all of those models have assumptions and data underlying them." Exploring the assumptions found in these models produces numerous questions from curious students.

Although many of his students are not comfortable with mathematics, Charles Welden, in the Department of Biology at Southern Oregon University, has them dive right into building mathematical models themselves. He has had limited success with prewritten computer programs, and he wants to avoid confusing his students with complex differential equations, so he has students use discrete-time difference equations in an Excel spreadsheet. They initially plug data into the basic formulas Welden provides, and they build from there. "They learn not only how the particular models work, and the assumptions that went into them," says Welden, who has coauthored books (with Therese Donovan) on using these spreadsheet exercises, "but also something about the process of modeling in general and its values and limitations."

Actively involving students in using models to solve real-world problems is another approach for generating student interest. Roelof Boumans, associate research scientist at the University of Vermont's Gund Institute for Ecological Economics, and Lisa Chase, director of the Vermont Tourism Data Center and natural resources specialist with University of Vermont Extension, team-teach a graduate-level service-learning course on tourism in northern forests. Chase facilitates rural community focus groups, and Boumans captures data and generates initial models using the STELLA model-building and simulation software. Their students work in teams to further build the models, present them to the community groups, and evaluate the process of model creation and use.

"Building models and working with community groups was completely new to many of us," says Stephanie Morse, one of the students in the course. She and her teammates mapped out relationships and added data to build their STELLA models. The students shared the resulting models with the community, allowing participants to visualize options in an interactive way and explore possible scenarios. The open-endedness of the real-world problem was a huge challenge for the students. "We realized that the process is quite risky," says Morse. "You can change one aspect of the data and get a completely different result." While Morse became more and more interested as the layers of the complex relationships grew deeper, some of her fellow students had the opposite reaction. "They grew more skeptical," says Chase. "It opened the students' eyes to the limitations of data and models."

Welden's students also quickly recognize the limitations of the basic population models he has them build at the beginning of the semester. The students know that simply adding new individuals (births) and subtracting others (deaths) is not a realistic representation of a population. As the students add carrying capacity, predators, competitors, and other factors, their models become more realistic and sophisticated. "The resulting models," says Welden, "are often more complex than those presented in standard ecology textbooks."

Once they are comfortable with models, students can be asked throughout the course to build models to demonstrate their understanding of ecological concepts. "Asking students to build a model of a system is a great way to assess whether [they] understand relationships between processes or the magnitude of different potential inputs to a system," says Ewing, who encourages faculty to incorporate models into courses. She and her colleagues coauthored "The Role of Modeling in Undergraduate Education," a chapter in *Models in Ecosystem Science* (see the box above) that discusses assessment and provides teaching recommendations.

Although there are many approaches to teaching modeling, the successful ones give students opportunities to create models before using them. "You cannot hand students the finished product; instead, guide them through the process," says Welden. Morse agrees that the students need to create models themselves. "We frequently got stumped and had to go to the instructor with questions," says Morse, but believes it was a valuable learning experience because she and her fellow students had to think through the entire process.

Teaching students to use models takes time, but the results are worth the effort. "Everyone has a model in his or her head," says Boumans, "but they rarely take the time to define the model." Students challenged to define models will hone their critical thinking and quantitative reasoning skills while learning to think of systems as a whole and of science as a process.

Resources for scientific modeling and undergraduate education.

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