Modeling Dynamic Systems: Lessons for a First Course
Webinar Q&A with Diana Fisher

Q: Do you incorporate modeling within your regular math classes such as Algebra I?

A: When I taught Algebra I ten or more years ago, I would incorporate some simple models (linear, quadratic, and exponential). But more recently, the students we get in Algebra I at the high school level are students who are not very successful in math. (Most students take Algebra I in 7th or 8th grade now.) The high school Algebra I students' math skills are so low that I do not try to do much outside the regular curriculum. Recently, I have only tried linear models with this level of student. That does NOT mean more modeling experiences would not work with an average or above average group of Algebra I students. I definitely think you could model exponential and quadratic time-based problems using the STELLA software in an Algebra 1 course serving students with average or above average mathematical skill, as a way to get general modeling concepts off the ground.

Q: Are there resources available for "best practices" on introducing middle and high school kids to modeling?

A: I do not know of "best practices" for modeling per se, but there are best practice suggestions that indicate the use of visual representations of problems is very effective. There are other best practice suggestions that are used throughout the modeling course, such as student-centered activities or exercises, students working in teams, and students explaining what their models or their graphs mean.

The Waters Foundation website, www.watersfoundation.org offers more explicit references to this topic. If you go to their website and search on "related best practice", you may find what you are looking for.

Q: I find it very interesting that you are not using causal loop diagrams and go directly to "the model"... can you talk more about it?

I found it took the students a long time to go from the causal loop to the modeling diagram. And I wanted them to get to the stock/flow model to do most of their analysis. I found I could cut the learning time in half by going right from the problem description to the model. That's the way Jay Forrester does his modeling. It is also the way some other world-class system dynamics modelers work. It is very straight-forward for students. I still have students do feedback analysis, sensitivity analysis, and explanations of interacting feedback when testing parameters. The students build causal loop diagrams after they build the stock/flow model. We still get to the same place. It works well for my students, so that is why I do it this way. In the System Dynamics method, there is no rule that says causal loops have to come before model-building (although there are some very gifted model-builders who do it that way).

Q: How much do you find you have to get involved in your students' researching their projects, or can you concentrate just on the techniques of modeling?

A: If students are having difficulty finding a topic or data, I merely act as another (very temporary) member of the team. Often students have chosen topics I know nothing about, so all I can do is suggest where I might start looking for such data, if it were my problem. I ask them questions to help them narrow their topics, but I try not to get very involved.

If students cannot come up with anything, I give them a copy of some core structures from the Appendix of the book — population dependent upon resource, disease transmission, supply and demand — and tell them they could find a specific application of one of these structure concepts and build from there. It is extremely useful to have students work in teams of two, so they can talk to each other to try to work out their problems. But the news articles assignments tend to help students get off the ground.

If I were just starting to teach a modeling course and did not have much experience myself, I would tell the students they had to limit their models to two or three stocks and keep them simple. (I try to do that now, as well, but am comfortable allowing students more leeway if they seem to understand what they are building. Still, simple is elegant, and almost always more useful.)

Q: How can we make this kind of mathematics learning available to all students, not just selected upper middle class students in a liberal area of the country? (P.S. most teachers and policymakers have no idea this kind of math exists!)

I started this modeling course in an inner-city school that served families of middle to lower socio-economic status. I started teaching the class to mostly juniors and seniors, but eventually concentrated on freshmen. At that school, at one point, we had three first-year modeling courses offered each year, and one second-year modeling course. BUT, the students had to be reasonably comfortable with math. They had to have completed Algebra I with an A or a B grade.

For students who were older I looked more for some self-discipline, ability to stay focused, and a strong curious nature as a personal characteristic they possessed. The class has never had discipline problems. But if a student was off task too often, sometimes I had to council the student out of the class.

Q: Aside from application of the syllabus, are there things you have found useful to helping students who struggle with the concept of systems thinking?

When a student is having trouble, I try to reformulate the problem as a simpler problem and help build them up to the issue that is difficult for them. It is hard for me to answer this question because Systems Thinking is such a broad topic.

Q: Do you have any indications/experiences about how useful your book is for self-study and distance-learning?

I wrote this book for high school teachers to teach high school students how to do SD modeling. 98% of the people buying the book do not fall into that category. About 49% of the people buying the book are from the business environment. I suspect they are using the book to teach themselves and/or provide beginning training in their organizations. Another 49% come from colleges and universities. I suspect they are using the book in the same way, to teach themselves and/or provide introductory courses in SD modeling.

Since I had to teach two courses during the same class period, in order to have the opportunity to teach the SD modeling course (in my current school), I had to develop the materials so they worked well for independent study. That has proven to be very successful. I have not tried the materials for distance-learning, but it is in my future plans.

Q: We've been struggling with a freshman (University) programming course for students of all areas. It seems to me that SD could be very useful. Have you experimented with combining SD with programming?

I think SD would be a great course for university freshmen from many disciplines. Since these students are supposed to have second year algebra in their background to be ready for the university, they should be comfortable enough with math to be successful. I would NOT suggest combining SD with programming, given my choice. I love both courses, BUT SD modeling is so far reaching, so much more accessible to a broad audience of students with many interests, connecting it to programming will label it as a computer nerd course (not that there is anything wrong with being a computer nerd!) and (I think) cause it to suffer the same issues as CS courses currently suffer. So many girls stay clear of computer science (in spite of all I have tried to do to entice and interest them in the subject). Girls LIKE the modeling course, because it can address problems they care deeply about — primarily health-related issues and environmental issues.

Q: Is your book appropriate for 8th graders?

It depends on the level of ability in the 8th grade class. There are two books created by a middle school math and a middle school science teacher titled *The Shape of Change* and *The Shape of Change, Stocks and Flows* that fit the 8th grade level well. It is not the same design as my lessons, but I really like these books. They start with an activity – so the students have a collective understanding of the dynamics of the activity. Then they build some simple causal loops as they analyze the activity. Finally, in the second book, they build simple stock/flow diagrams for the activities. The books are published by The Creative Learning Exchange (www.clexchange.org) and are also sold by isee systems. Depending upon the level of student you are talking about, a combination of these books and some of my lessons could be useful.