

PORTLAND STATE UNIVERSITY
Systems Science Graduate Program
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MW 18:40 - 20:30
CRN 64322
Neuberger Hall 437
Office Hours: TH 11:00-13:00
or by arrangement

Models in the Natural and Social Sciences (SYSC 510)

This interdisciplinary course focuses on the role of models in scientific inquiry. Students explore how scientists from a variety of disciplines use different types of models, including physical (scale), mathematical, agent-based, and animal. To facilitate this exploration, the course is divided into three main sections.

1. **Definition:** We compare different definitions of “science,” “the scientific method,” and “model.” Here we also look briefly at what philosophers of science have said about how models fit into scientific inquiry.
2. **Deconstruction:** Students critically analyze a variety of models used in the research literature from different disciplines. Key questions include: What are the strengths and weaknesses of models as tools for posing and answering scientific questions? Which types of modeling techniques are best for investigating different types of scientific questions? What common issues apply to the use of all scientific models? How should one evaluate models in terms of the tension between fidelity to the “real world” and their necessary (and desirable) simplifications? What validation procedures are necessary to increase confidence in model generated results?
3. **Construction:** Students identify a scientific question of interest and propose a hypothesis that a model could help to test. They then design, construct, and use their model to address their question. This construction phase defines the main course project which is staged over the term.

The course provides both a conceptual understanding of how models are used in science and “hands on” experience conducting scientific inquiry using models as tools.

Assignments and Tests

Course assignments are divided into three main categories: 1) several short homework assignments mainly focused on hands-on experience with different types of models, 2) a group project (Project 1) focused on the Definition and Deconstruction sections of the course, and 3) an individual main project focused on the Construction section with several intermediate deliverables (Project 2). More details below.

1. **Homework (group, pairs, and individual):** There will be several short homework assignments. The general idea behind these assignments is to reinforce and extend activities begun in class (e.g. by extending a model developed in class or commenting on

a guest presentation).

2. **Project 1 (group):** This project has two components corresponding to Definition and Deconstruction sections. In the first component, groups are assigned two disparate subject areas (e.g., chemistry and epidemiology). They find research articles in each area that use models and then compare and contrast them. In the second component, groups look for additional articles in one of these subject areas and look for articles that use very different modeling approaches to model the same target system. They analyze these differences including how the choice of different modeling approaches may lead to different emphasis and conclusions.
3. **Project 2 (individual):** This is the main modeling project in which students design, implement, and use their model to help address a scientific question of their choosing. This choice is guided by the instructor through discussion and an iterated proposal process. The project is staged over the term with several deliverables along the way. These include:
 - *Inspiration:* Early in the term students start to brainstorm about a topic they would like to research using a model. Students provide a one-page synopsis introducing their phenomenon and explaining what questions they have about it. They receive feedback from the instructor and peers.
 - *Proposal with Literature Review:* Using feedback gained in the review of their inspiration statements and additional research addressing their chosen phenomena or question, students provide a brief research proposal clearly stating their research question. Students choose and justify which modeling method and tool they will use to address their question.
 - *Prototype:* Students demonstrate a rough mock-up of their model. At this point the model need not be sufficiently developed to answer their research question, but should be far enough along so that it can reproduce the phenomenon under investigation in some essential way.
 - *Demonstration:* Students demonstrate their final model, including how the model generates data that addresses their original research question. Students also answer questions about their models' inner workings.
 - *Poster:* Students prepare visually attractive presentations of their original questions, models, and main conclusions in an uncomplicated manner. In addition students prepare short presentations to be delivered to visitors to their poster.
 - *Report:* Students write reports, including an abstract, figures, tables, and references. A report template will be provided with headings, page limits, and formatting requirements.

Expectations and Focus: It is not expected that students will necessarily do publishable science or answer novel research questions with their model (although this does happen). The goal is to push students to participate in the process of doing science with models at the level at which they are capable. In this course we aim high, but are realistic about where we are likely to end up given the prior preparation of students and the time available.

4. **Final Exam:** There is a straightforward final exam that gives students a chance to converse in the language of the course. They synthesize the main themes and structure of the course in the following way:
- Students are asked to define “science,” “scientific method,” and “scientific model” in their own words.
 - Then given a few brief excerpts from research articles they are asked to choose one and deconstruct the model described in the excerpt: Which type of model is used? What assumptions and simplifications are made in the model? Does the model capture enough of the natural phenomena to address the research question—why or why not? Do the authors adequately verify that the model accurately captures these key elements of the natural phenomena? Do they validate model results with findings from nature?
 - Finally, given a few brief descriptions of natural phenomena and associated research questions, students choose one phenomenon and outline how a model might be useful in addressing the research question.

Readings

Reading will include original research articles that utilize models (found by students) as well as some reading assignments posted on the course website (these may be drawn from the following):

- Bird, Alexander (2008), "Thomas Kuhn", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2008/entries/thomas-kuhn/>.
- Frigg, Roman and Stephan Hartmann (2008), "Models in Science", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2008/entries/models-science/>
- Godfrey-Smith, Peter (2006), The strategy of model-based science, *Biological Philosophy* 21:725–740. URL = <http://www.people.fas.harvard.edu/~pgs/PGS-StrategyMBS-06.pdf>
- Godfrey-Smith, Peter (2009), Models and Fictions in Science, *Philosophical Studies* 143:101–116. URL = http://www.people.fas.harvard.edu/~pgs/PGS_ModelsFictions-09Final.pdf
- Milner, Richard and Vittorio Maestro eds. (2002), Special issue: Intelligent Design? *Natural History* 111, Issue 3.
- NetLogo User Manual (e.g. <http://ccl.northwestern.edu/netlogo/docs>)
- Otto, Sarah P. and Troy Day (2007), *A Biologist's Guide to Mathematical Modeling in Ecology and Evolution*, Princeton University Press. Chapter 1 available from publisher online. URL = <http://press.princeton.edu/chapters/s8458.pdf>
- Thornton, Stephen (2008), "Karl Popper", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2008/entries/popper/>.

Policies

Prerequisites: Basic Algebra, Logic skills, and familiarity with research articles (calculus, linear algebra, and/or programming skills may be useful depending on the type of model chosen for the final project, but are not required).

Course Website: To access this site go to <http://bb.pdx.edu/> and login with your PSU ID. Additional readings and relevant links will be posted here, as well as the most up-to-date version of this document.

Class Requirements and Policies:

1. **Preparation:** Much of class will involve participation in discussions. You cannot participate fully if you are not prepared. Please do assigned readings before they are due. Readings will be posted on or linked to from the course website.
2. **Late Assignments:** Coursework is due at the start of class on the due date. Late assignments will be marked down for each day they are late. In case of unavoidable circumstances, please contact me via email before the due date.
3. **Disability Notice:** If you have a disability and are in need of academic accommodations, please notify me at the beginning of the course. For information on available disability services and required documentation, please visit <http://www.pdx.edu/iasc/drc.html> or call the Disability Resource Center at (503) 725-4150.
4. **Grading:** The approximate breakdown of graded work will be as follows:

Participation (including leading discussion)	10
Project 1: Deconstruction (group)	20
Project 2: Construction (individual)	40
Homework Assignments (individual and pairs)	15
Final Exam	15
Total	100

Tentative Schedule (subject to change)

Section	Week	Topics	Project Milestones*
Definition	1 (3/30)	- Course orientation, introductions - Definitions of science; - Science in context—other ways of knowing - What makes a theory scientific?	Proj. 1 (group) W
	2 (4/6)	- Types of models - Definitions of model - Proj. 2: Brainstorming - Taxonomy of models	Due: Proj. 2 Inspiration W
Deconstruction	3 (4/13)	- How models fit into scientific method - Analytic models	Due: Proj. 1.1 W
	4 (4/20)	- Numeric Models - Dynamics: basic principles	Due: Proj. 2 Inspiration (revised) M Due: Proj. 1.2 W
	5 (4/27)	- Agent-based Models - General modeling tips: what to put in; what to leave out	Due: Proj. 2 Proposal with lit. review W
Construction	6 (5/4)	- Physical (e.g. scale) Models	
	7 (5/11)	- Model Organism Systems - Model Verification	Due: Proj. 2 Prototype
	8 (5/18)	- Animal Models (of human) - Model Validation; Poster Design	
	9 (5/25)	- Monday 5/25 is Memorial Day Holiday - Proj. 2: Demo	Due: Proj. 2 Demo W
	10 (6/1)	- Proj. 2: Poster Session - Review of strengths and weaknesses of models as scientific tools	Due: Proj. 2 Posters and Presentations M
	11 (6/8)	Final Exam Monday June 8 (19:30-21:20)	Due: Proj. 2 Report (at Final)

***Homework assignments and due dates will be announced in class**

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