Systems Thinking for Sustainable Development and Enterprise

Syllabus

Course Number: EAS550; Strategy 566
Term: Winter 2019
Course Time: Mondays & Wednesdays, 10:00-11:30 am
Location: 2520 Dana

Instructor: Prof. Ming Xu
Associate Professor, School for Environment and Sustainability
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Instructor Office Hours: By appointment

Graduate Student Instructor: Chenyang Shuai
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GSI Office Hours: Mondays, 4:00-5:00 pm, Dana 3325

Course Objectives:

(1) Students will develop critical skills in **global systems thinking**, with global defined as relating to the entire world, as well as embracing all considerations of complex systems.

(2) Students will develop skills in **system dynamics modeling** using STELLA software.

(3) Students will develop awareness in issues related to **global environmental and social change**.

(4) Students will deploy system analysis skills in **business applications**.

Enrollment Qualifications

Graduate students are eligible for this course, with enrollment preference given to SEAS and Ross students. There are no pre-requisites for this course.

Course Materials

1. John Sterman, **Business Dynamics: Systems Thinking and Modeling for a Complex World** (Irwin Mcgraw-Hill, 2000). *Note: This text is very expensive if you buy it new. Shapiro Library has reserved five hard copies of this text. You will not need the associated CD that comes with the text, so if you wish to own the text, I recommend buying it used if possible.*
2. Donella Meadows, **Thinking in Systems: A Primer** (Chelsea Green Publishing, 2008)
3. **STELLA Professional/Student**, $59 for six month license; $129 for perpetual license (details on purchasing process to be discussed in class)

Grading

15% - Class participation, as determined by attendance, periodic in-class exercises, and participation in discussions.
30% - Individual assignments (3)
25% - Group project interim deliverables (4)
30% - Group project final report

Class Policies

- Course materials will be made available on Canvas.
- For individual assignments, you may discuss problems and solution approaches with your peers, but work should ultimately be your own. If you choose to discuss assignments with your peers, list their names on the submission.
- Assignments and reports are due at the beginning of class. Late assignments will be accepted up to 48 hours past this deadline at a penalty of 20%. Assignments will not be accepted more than 48 hours after they are due.
- All references must be appropriated cited.
- Challenges to grades must occur within one week of the return of the assignment. Challenges must be in writing and will result in a complete regrading of the assignment (i.e., scores may increase or decrease).
- Attendance is expected. If you have the need to miss a class, contact the GSI and I prior to the class. One absence, with notification before the class starts, will be excused without penalty.
- If you need accommodation for any disability that affects your performance in this class, please contact me as soon as possible.
- Electronic devices should not be used in class with the exception of laptops for note taking and modeling.
- Email policy: Questions about assignments should be directed to Chenyang Shuai at cyshuai@umich.edu with [EAS550/STRAT566] in the subject, cc' mingxu@umich.edu @umich.edu. Questions and associated answers may be shared with the entire class.

Communities Values Statement

Personal integrity and professionalism are fundamental values of our University community. The Ross Academic Honor Code (www.bus.umich.edu/Academics/Resources/communityvalues.htm) provides comprehensive information on how to avoid academic misconduct and how be sure that you have not plagiarized the work of others. This course will be conducted in strict conformity with this Academic Honor Code. Claimed ignorance of the Code and related information appearing on the site will be viewed as irrelevant should a violation take place.

Course Outline

Session	Topic	Readings
[1] 1/9&14	**Introduction to Systems Thinking**	
	• Course details • Global system pressures • Meanings of sustainable development • Business case for sustainability *In-class: Beer production-distribution game*	• United Nations "Sustainable Development Goals" 2015. • Sterman, Ch 1 • Meadows, Introduction
	Learning objectives: Introduction to systems thinking and sustainable development; "structure produces behavior"	
[2] 1/16&23	**Modeling Process and Causal Loop Mapping**	
	• Dynamic hypothesis • Model simulation and testing • Reinforcing and balancing loops • CDL notation and polarity *In-class: Policy resistance CLD; team matching*	• Sterman, Ch 3 • Sterman, Ch 5.1-5.4 • Meadows, Ch 1
	Learning objectives: Explore the process of system dynamics modeling; understand the role of feedback and develop diagramming skills to capture the structure of systems	
Due 1/28: Individual Causal Loop Mapping Assignment (Fukushima)		
[3] 1/28&30	**Stocks and Flows**	
	• Stocks, flows, and accumulation • Mapping stocks and flows • Intro to stocks and flows dynamics *In-class: Fukushima workshop; greenhouse gas accounting; population dynamics*	• Sterman, Ch 6 • Meadows, Ch 2
	Learning objectives: Introduce the concept of stocks and flows in systems; modeling behavior and relationship between stocks and flows	
Due 2/6: Individual Archetype Assignment		
[4] 2/4&6	**Structure and Behavior of Dynamic Systems**	
	• Exponential growth • Goal seeking • Oscillation • S-shaped growth • Overshoot and collapse • "Systems zoo" *In-class: Archetype workshop; dynamic hypothesis workshop*	• Sterman, Ch 4.1-4.2 • Meadows, Ch 5 • Braun "System Archetypes"
	Learning objectives: Build an understanding of the relationship between system structure and behavior; identify modes of behavior in dynamic systems; review representative system types	
[5] 2/11&13	**Dynamics of Stocks and Flows**	

	• Static and dynamic equilibrium • Linear first order systems • Positive and negative feedback • Doubling times and half lives *In-class: Labor force dynamics; epidemic modeling*	• Sterman, Ch 7.1-7.2 • Sterman, Ch 8
	Learning objectives: Modeling behavior and relationship between stocks and flows	
Due 2/20: Individual Modeling Assignment (Easter Island)		
[6] 2/18&20	**Dynamics of Growth**	
	• S-shaped growth • Phase plots • Tipping point • Path dependence and positive feedback *In-class: Easter Island; innovation diffusion*	• Sterman, Ch 9 • Sterman, Ch 10.1-10.2 • Meadows, Ch 4
	Learning objectives: Understanding how S-shaped growth models apply to models for innovation, infectious disease, and markets for new products; identifying system characteristics that lead to path dependence and lock-in	
Due 2/27: Group project: Dynamic hypothesis and causal loop diagram		
[7] 2/25&2/27	**Dynamics of Renewable Resources and the Tragedy of the Commons**	
	• Overshoot and collapse • Misperceptions of feedback • Tragedy of the Commons *In-class: Fishbanks*	• Fishbanks Video
	Learning objectives: Gain experience with resource dynamics; illustrate misperceptions of feedback; discuss governance of the commons	
WINTER TERM BREAK		
[8] 3/11&13	**Delays and Aging Chains**	
	• Material and information delays • Aging chains' structure, impact *In-class: Delay exercise*	• Sterman, Ch 11.1-11.5 • Sterman, Ch 12.1
	Learning objectives: Understanding the role of stock and flow attributes (such as age of items) on system behavior; understand the structure and behavior of delays.	
Due 3/20: Group project: Delay example		
[9] 3/18&20	**Modeling Nonlinearity and Instability**	
	• Formulation, shapes, and values for nonlinear relationships • Instability in supply chains • Planetary boundaries	• Sterman, Ch 14 • *Resource for model validation and testing: Sterman, Ch 21*

	• *In-class: Climate change feedback acceleration*	
	Learning objectives: Methods to estimate nonlinear functions; understanding stock management in supply chains and the origin of oscillations; risks of exceeding planetary boundaries	
Due 3/27: Group project: Nonlinearity example		
[10]3/25&27	**Modeling Decision Making and Human Behavior**	
	• Principles for modeling decision rules • Bounded rationality and decision-making capabilities *In-class: Decision making exercise*	• Sterman, Ch 13.1 (rest of chapter is good reference) • Sterman, Ch 15.1-15.4
	Learning objectives: Learn modeling techniques to create realistic decision makers, consistent with actual decision-making capabilities.	
[11] 4/1&3&8	**Global Change – Team Presentations**	
Due 4/15: Group project: Decision making/human behavior example		
[12] 4/10&15	**Designing and Managing Resilient Systems**	
	• Resilience • Self-organization • Hierarchy • Robustness • Adaptive capacity • Leverage points in a system • "Systems wisdoms" *In-class: Model peer review*	• Sterman, Ch. 17 • Meadows, Ch 6 and 7
	Learning objectives: Identify characteristics of highly functional systems; identify places to intervene in a system and recognize counterintuitive leverage points; reflect on systems wisdoms	
[13] 4/17&22	**Negotiating a Complex World**	
	In-class: World Climate	• World Climate prep
	Learning objectives: Connecting physical and behavioral aspects of systems	
Due 4/29: Group project: Final report and model		