

FORE 6333 Systems Thinking

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Welcome to our course on Systems Thinking. Without making too big deal of it, this course may be one of the most important courses you ever take. Many graduates of the futures studies program have reported that this course changed their view of the world — forever. But you might ask, From what? And to what?

Content

The change they experienced is described in Systems Theory: System Behavior Is a Function of Its Structure, a reading in the Foundation Documents for the course. The System Behavior document is what the course is about, in one statement. Briefly, things happen in the world, not because of individual people and what they do/did or because of outside forces although both those things do sometimes happen. Rather the better explanation is usually that the "system" "behaves" that way because of its "structure." In other words, it's supposed to behave that way because that's the way it has evolved or been designed. The whole course then is understanding what we mean by a system, the behavior of a system, and the structure of a system.

To quote Albert Einstein, "For all the complicated things in the world, there exist simple explanations, most of which are wrong." The world is a complicated place. We simplify it so we can understand it. As a result, we blame people for the fact that the government, the economy, the parks department, the schools don't run (i.e., behave) the way we think they should. We blame the government (again), our parents, foreigners, the weather, and other external forces for making life difficult for us. When we get right down to it, however, systems operate just the way they evolved or are built (i.e., structured). They are just doing what they do. It's no one's fault; there is no conspiracy. They are just being what they are.

But to understand what they are (i.e., how they are structured) takes some doing because the structure is not obvious. You can't see it with your eyes or touch it with your hands. Rather you "see it" with the mind's eye. And that is what our graduates have told us. Once they "saw" the operation of systems in the world, they could not un-see them again.

Approach

Seeing is a skill. We do not learn skills from lectures. We learn skills, like riding a bicycle, solving a math problem, or raising a child, by doing it over and over again. We learn faster when we get a little instruction at the beginning, like how to hold our feet on the bike, and feedback from someone who knows how to do it, like how to change the baby's diapers. So we are going to employ the same approach here — a little instruction, practice and feedback — and before long, you will be seeing systems all over the world as well.

But the approach for this course is unique. I've been teaching this course since about 1990 with brief respites from Andy Hines, Draper Kauffman and a few others. But I am more excited about the course this year and last more than most I have taught. The excitement is that this course will actually be two courses in one.

The traditional course was based on a cybernetic perspective on systems. Cybernetics arose in the 1940s as control theory, mathematical equations that described the behavior of machines. Those equations formed the basis of systems engineering which is, in turn, the basis of most of the complicated machines we have in our world today—from computer chips to the International Space Station. That theory was first applied to human systems in the 1960s and still works as an excellent way to view systems.

In the 1990s, I learned and added a second perspective on systems--agent-based or complex adaptive systems (CAS). That perspective was also invented in the 1940s, but it was not until the 1980s that computers became powerful enough to simulate the operation of these systems. (The behavior of these systems can only be simulated; they don't have the equations like the cybernetic approach does.) This semester, we can actually get a mini-course on [Complexity](#) from the intellectual center of CAS, the Santa Fe Institute. They are teaching a free, open, online course beginning Jan 28 which we can take as part of this course. We also supplement the SFI course with sections of another systems course from the University of Michigan called [Model Thinking](#). The structure of the course will be cybernetics for the first two-thirds of the course (mid-Jan through March) and CAS for the last third (April through mid-May).

The instruction for the course will come primarily from textbooks. There are whole libraries written about systems thinking so we have selected only the best for you here:

Reading

Cybernetic systems

Draper Kauffman, ***Systems One*** and ***Systems Two***

An outstanding introduction to systems thinking — short, simple, practical, full of great examples. You will continuously refer back to this book. Draper has let us put these books online. Here is [Systems One](#).

Donella Meadows, ***Thinking in Systems***

Donella (Dana) Meadows wrote ***The Limits to Growth***, a milestone study of the world system back in the 1970s. To everyone's astonishment, it sold several million copies in over 40 languages and earned her and her colleagues a Pulitzer prize. (See additional readings, below.) Until her untimely death, she was also one of the best practitioners, teachers and advocates for systems thinking.

[Gene Bellinger](#), ***Beyond Connecting the Dots***

An ebook that describes the whole course using text and interactive examples.

Virginia Anderson and Lauren Johnson, ***Systems Thinking Basics***

An excellent how-to book on systems thinking and one of the tools we will learn — causal modeling. Full of simple explanations and great activities.

Complex adaptive systems

Melanie Mitchell, ***Complexity: A Guided Tour***

The book version of the online course from the Santa Fe Institute taught by Dr. Mitchell that we will use during the last third of the course.

Mitchell Resnick, ***Turtles, Termites and Traffic Jams***

Watching other people model systems is nothing like doing it yourself. Resnick and others at the famous MIT department that invented systems dynamics has taken an instructional program called Logo and turned it into a CAS modeling program called *StarLogo*. With *StarLogo* you can program your own CAS and see what emergent properties they have. [SFI uses Netlogo, a very similar program. We'll see some NetLogo examples as well, but Resnick's descriptions are still the best IMO.]

Model thinking -- These are books that Scott Page recommends in Model Thinking.

- [The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies \(New Edition\)](#), Scott E Page
- [Complex Adaptive Systems: An Introduction to Computational Models of Social Life \(Princeton Studies in Complexity\)](#), John Miller and Scott Page
- [An Introduction to Models in the Social Sciences](#), Jean Lave and James March

Recommended Reading

Peter Senge, Kleiner, Roberts, Ross, and Smith, ***The Fifth Discipline Fieldbook***

The classic is Senge's *Fifth Discipline* — the bible of systems thinking. Senge then collaborated with some of his friends to produce *The Fieldbook* with the same message, but lots more stories, examples, tools and techniques.

High Performance Systems, ***An Introduction to Systems Thinking***

Another good introduction to systems and an introduction to one of the other tools we will learn — systems dynamics. More conceptual, but HPS includes a tutorial on building an actual computer model of a system using their tool — Stella. [You can purchase and even download the book from [iSee Systems](#). It has a good theory section and an excellent tutorial on system dynamics modeling. It uses the Stella software which some purchase rather than the free download of Vensim, but they are almost identical--Stella just has a few more bells and whistles.]

Donella H. Meadows, Jorgen Randers, Dennis L. Meadows, ***Limits to Growth: The 30-Year Update***

One of the blockbuster futures books of the 1970s was *Limits to Growth*. In that book, Donella Meadows and others shared a computer model of the world that demonstrated that resource consumption would eventually destroy the world system unless something was done. Well, we haven't sunk yet, but Meadows and her colleagues are back saying that the problem still exists. *Limits to Growth* and *Beyond the Limits* are the most effective systems models that have changed people's thinking about the future of the world. They show how systems thinking and modeling can affect policy making, but we do not have an activity associated with the book. [You can find a good online synopsis at <http://dieoff.org/page25.htm>. I've also just written a book review of all three.]

Joshua Epstein and Robert L. Axtell, ***Growing Artificial Societies***

ugarscape is to CAS what *Limits to Growth* is to cybernetic systems--the best known large-scale application of that modeling approach. It is a classic modeling of the world system using a set of ants

with a taste for sugar and spice. From that simple formula, the authors show the emergence of tribes, trade, war, and other phenomena that make up our daily lives.

Draper Kauffman has also recommended some other [books](#) as well.

You can obtain most of these books in a number of ways: from [Amazon](#) or [Barnes and Noble](#). Kauffman's book will be available online within the course.

There are **other resources** as well. These web sites, in particular, have great instruction or resources for systems thinking:

- [Bellinger](#) — another good intro systems to systems thinking and causal modeling
- [Radzicki](#) — a introductory book on system dynamics
- [Ford](#) -- a whole course on a system dynamics model of the environment
- [Roadmap](#) — the complete course in systems dynamics from the people who invented it

System dynamics models:

[Fiddaman](#) — System Dynamics Model Library

Portals to other system dynamics resources:

- [MIT Systems Dynamics Laboratory](#)
- [Systems Dynamics Society](#)
- [System Dynamics / Systems Thinking Mega Link List](#) by Günther Ossimitz

Software

You will need the following programs to be able to read the material and do the assignments of this course:

- ***A web browser (Internet Explorer, Firefox, Chrome, etc.) with the [Acrobat Reader](#) plug-in and the [Macromedia Flash Player](#) plug-in, both of which typically come with the browser***
- ***Microsoft Word (or its equivalent that can read Word 1997+ documents)***
- ***Microsoft Excel (or its equivalent that can read Excel 1997+ spreadsheets)***
- ***Microsoft Paint, PowerPoint or any drawing program that can be used to make graphs and illustration***
- ***[Vensim PLE](#) (available free)***
- ***[Netlogo](#) (available free)***
- ***[Insight Maker](#) (requires free account) -- a new cloud-based model building tool that improves on both Vensim and NetLogo***
- ***[WinZip](#) software or some way of compressing and decompressing files (built into Windows 7/8)***

Interaction

Staying in touch during a course like this is one of the most important aspects to its success. To that end, we have a number of ways of communicating.

Website

Most of the formal interaction in the class takes place through the website, such as instructions, readings, activities, submissions, feedback, etc. We will be using the Canvas Learning Management System, which will be new to some, but infinitely easier to use than Blackboard. Canvas even has an iPhone app that you can use if you wish. You will get an email invitation to the course before the first class.

Activities

There are a number of activities to turn in every week. The purpose is to practice the learning and techniques. I will work to get you feedback if there is something to say about it. I read every activity, however, so no feedback does not mean it's not important. Just that it was fine, and you are making good progress. But each activity is an occasion for dialogue about what we are learning and how we are doing so please let me know if you have questions or issues with an activity.

Discussion Boards

All of the activities are posted on the Discussions Forums. Be sure to keep up your posts and comments in Discussions. Everybody gets behind once in a while; I do as well. We just don't want a temporary setback to result in permanently failing to complete the course.

The good thing about posting on Discussions is the opportunity to see what other students are doing and what I am saying about that. But don't worry—no harsh criticisms; just what I would have said in class were to go over it that way. It's also a good opportunity for you to comment on or ask questions about each others' work. There's teaching and learning going on in the Discussions just as much, and perhaps even more than in the classes.

I've also created [The Learning Company](#), a special Discussion Topics, to expedite our dialogue about the course. Keeping up is one thing. Reflecting on one's learning is another. Anything you come across—a reading, a scanning hit, an aha! insight—that doesn't seem to fit in a specific week is fair game for sharing with us in the Learning Company.

You can also post issues with the course itself on The Trouble Spot. Unfortunately, I don't get notified of postings on those, but I do get notified of internal emails so send me an email if the issue is urgent.

Assignments

*Another way to submit materials is through Assignments. [The names of Discussion Boards are in **RED**; the names of Assignments are in **GREEN**.] Assignments submit your material directly to the instructor. It's not that anything is private there, but some activities are so simple that just about everyone will come up with the same thing. You also post your Portfolios that way.*

Email

Of course, the best person-to-person communication is email. The Inbox on Canvas is exceptionally good, and I get a text every time someone sends me a message.

Technical Support

There is no real Help Desk for Canvas since it is a free service to us. But the Help function does a great search of all the manuals and guides. And I have gotten a good response from the Canvas people on the rare occasion I have had to contact them. Your instructor, however, is the first line of technical support. For this year, *it's* The Trouble Spot, Canvas Inbox, UH email (pbishop@uh.edu), text or phone (281-433-4160)

Class

Those in Houston may also attend class on every Wednesday evening. (Class! How 20th century!) Classes are held from 5:30 to 8:30 pm US Central Time in Room 229 of the Cameron Building (corner of Cullen and Wheeler) on the UH campus. (That's UTC/GMT -6 until mid-March and -5 thereafter.) The class sessions will support what we are doing on the Web with face-to-face discussion and hands-on practice.

Teleconference

We also have an computer link set up during class. We will be using the university's licensed service called Adobe Connect that not only offers two-way voice interaction, but also projects PowerPoints and the desktop as well.

This year, we are trying an experiment to make the discussion in the classroom more accessible to those online. (The room mike is not very good.) So we are asking everyone who comes to class to bring an Internet device and a headset with mike. That way we don't have to pick up sounds from across the room. Not sure that will work, but it will be a big improvement if it does.

So do the following before the first class –

1. Get a headset with a mike and headphones. Some desk speakers and mikes create feedback so be ready with the headset just in case.
2. Get a browser that works with the Adobe plug-in. I use Firefox and others use IE. Chrome had a bug that didn't work well with the plug-in, but that may be fixed by now.
3. Test your bandwidth and download the Add-in at https://hdcs.adobeconnect.com/common/help/en/support/meeting_test.htm. Log You should have ain to <http://uh.adobeconnect.com/world>.
4. Click on the [Audio Call-in](#) link on the Homepage and configure your browser correctly
5. Test your audio by running the Audio Setup Wizard under the Meeting menu on the top left tool bar.
6. Learn how to mute your mike and adjust your volume.
7. Get or use the built-in camera so we can see your lovely face!

We also record the class for students who have a regular conflict with class time (work or other responsibilities). The link to the recording will be posted under Recordings on the Home page immediately after class.

For more information, check out the [Student Guide](#).

Telephone

Sometimes direct voice-to-voice communication is best to get an immediate answer or to go into an issue or problem in depth. Call or text +1-281-433-4160 for assistance.

So, the point is: Don't be a stranger! There are multiple ways to communicate. Let's use the ones that are most effective for you.

Submitting work

Different types of activities require you to submit your work in different ways. The two primary methods for turning in work is a post on a **Discussion Board** or on an **Assignment Dropbox**. The default is posting to the Discussion Board *so we can all see how smart you are*, but also so we can learn and discuss material that we are all working on. The Assignments section sends the product directly to the instructor. For postings, be sure to post in the correct Discussion Board so your colleagues can see your brilliant work and so I can give you credit come the end of the semester.

Each week includes a set of activities and products. Those are due on Tuesday evening at midnight so the instructor can review them before class. Assignments submitted after that will receive partial credit (losing 10% per week on the timeliness score) so turning it in late is better than not turning it in at all.

Grades

OK, we now come to the most important part of the course (for some, anyway). We are all in this to learn, but the State of Texas requires me to give you a grade so we have to have a way of assessing the quantity and quality of what you do.

Your grade will be determined by the quality and timeliness of the work you submit. The instructor will review each piece you turn in and, and you will receive feedback if there is something important or interesting to say (not always, but often). If it is not OK, you can redo it and make it right. When submitting an assignment a second time, it is usually a good idea to explain what you changed about the assignment and, even more importantly, what you learned in doing so.

The final grade is based on a portfolio of your work throughout the semester. It has four parts--

- The **first** part consists of 12 products from the course, the best product from each week with an annotation why you picked that piece and what you learned in doing it.
- The **second** part consists of a pair of quizzes dealing with key concepts and vocabulary, one for cybernetic systems, one for agent-based systems.
- The **third** part is a cybernetic systems analysis of an interesting system behavior of your choosing. You may choose one of the puzzlers from the beginning of the course, a system within your domain or any other system that gives you the opportunity to demonstrate what you have learned in this course. The objective of the analysis, along with it being technically correct, is to be able to say something new and interesting about the system that was not apparent when you began the analysis. The parts to the systems analysis are –
 - The name of the system
 - The source(s) of any data you have about it

- The system behavior to be explained, preferably in the form of one or more graphs
- The structure of the system that produced that behavior in the following forms:
 - A verbal description of the structure (different from the behavior)
 - A formal model of the structure in either causal model or stock-flow form with an explanation of the most important parts--e.g., feedback loops, etc.
 - A working computer model of the structure, *demonstrating the baseline behavior and at least two other alternative behaviors* as graphical output of the model. One of the alternatives is based on changing the parameters (the numbers) in the model; the other is based on changing the structure (the relationships) in the model (The computer model is optional, but it is required to receive an A for this assignment and for the course.)
 - A final explanation of the behavior as a function of the structure, emphasizing the new insights that the analysis revealed.
- The **fourth** part will be the analysis of an agent-based system using one of the examples from NetLogo. That report will follow the cybernetic approach although it will be less detailed because you will not have as much control of a model that you didn't build yourself.
- The **fifth** part is an essay that describes what you learned in the course, using the material you submitted as evidence of your learning. Highlight the best stuff and make a good case for what you learned and what you did.

Optional draft portfolios are due by midnight on Wednesday, April 30. The instructor will review the draft portfolio, including grades, and return it to the student within 72 hours of submission. Students then have the choice to re-submit any of the materials from draft portfolio as a final portfolio which is due the following Wednesday, May 7. Re-submitted assignments should include a note on what has changed.

Grading procedures

The final grade will be a combination of the quality and timeliness of your submissions, the quality of the final systems analysis and the quiz scores.

The quality of the submissions will be calculated as the average of the 12 submissions in the portfolio on a four-point scale where 4 is an outstanding submission, 2 is an average one and 1 is a poor one.

The calculation of the final grade looks like this –

12 weekly products	20%
Cybernetic quiz	10%
Cybernetic model (with optional simulation)	35%
Complexity quiz	10%
Complexity model (with optional simulation)	15%
Learning essay (optional)	10%

Timeliness will be calculated as 10 points for each submission turned in by the deadline. The score is a percent of the total possible points if everything were turned in on time. That percent may modify the final grade, up to one-third of a letter grade.

Other policies

Academic honesty policy All UH students are responsible for knowing the standards of academic honesty. Please refer to the UH catalog. Plagiarism, using research without citations or using a created production (such as other people's words) without quotations or citations, will result in a grade penalty or failure of the course. Internet sources must be credited according to the sites recommended citation guideline if available. If no citation guideline is provided by the web source, then the date, URL site owner, and author must be included with the web material used.

Disabilities: If you have a disability and need a special accommodation consult first with the Coordinator of Health Disabilities Services,

Incompletes: A grade of "I" is given only in cases of documented emergency or special circumstances late in the semester, provided that the student has been making satisfactory progress. An Incomplete Grade Contract must be completed.