Expanding Your Toolkit

Developing Critical Thinking Skills with Systems Dynamics

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Overview

• Background - White Mountain School
• Key concepts in systems thinking
  – Characteristics of a systems thinker
  – Behavior over time/Time horizons
  – Feedback (non-linear causality)
  – Unanticipated consequences
  – Leverage points
• Four sample assignments
What is Systems Thinking?

- “seeing interrelationships (feedback loops) instead of linear cause-effect chains”
- “seeing processes of change over time, rather than snapshots”
- “helps thinkers see things on three levels: events, patterns of behavior, and system structure.”

(From Road Maps Glossary)
The Ways of a Systems Thinker\textsuperscript{1}

- Sees the whole picture
- Changes perspectives to see new leverage points in complex systems
- Looks for interdependencies
- Considers how mental models create our futures
- Pays attention and gives voice to the long-term

\textsuperscript{1} As written by L.B. Sweeney and D. Meadows in \textit{The Systems Thinking Playbook} (1995)
The Ways of a Systems Thinker

• “Goes wide” (uses peripheral vision) to see complex cause and effect relationships

• Finds where unanticipated consequences emerge

• Lowers the “water line” to focus on structure, not on blame

• Holds the tension of paradox and controversy without trying to remove it quickly

1 As written by L.B. Sweeney and D. Meadows in The Systems Thinking Playbook (1995)
Key Concepts to Systems Thinking

- Behavior over time / Time horizons
- Feedback loops
- Unanticipated consequences
- Leverage points
Behavior Over Time

- Behavior emerges from system structure

Image Source: http://www.anselm.edu/homepage/jpitocch/genbios/52-19b-PopCycleHareLynx-L.gif
Behavior Over Time

• Time horizons matter

**Image source:** The Climate Ark, Overview of Climate Change vital graphics. http://www.climateark.org/vital/02.htm

**Image source:** World Resources Institute. http://images.wri.org/chart_scan_cni_f04b.gif

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Feedback

- Non-linear causality

**Reinforcing Loop**

(Positive Feedback)

**Balancing Loop**

(Negative Feedback)
Unintended Consequences

- Ask “and then what?”

Diagram:
- Discipline Hrs.
- Compliance with expectations
- Anger with “the system”
Leverage Points

• Small effort, large effect

Parameters
Information flows
Paradigm shift
Critical Reading and Analysis

• The End of Poverty by Jeffrey Sachs
• Review basics of causal loops
• Close reading – identify and draw causal loops
Simulation and Analysis

- Fish Banks, Ltd.
- Simulation game
- Debrief using systems thinking
Fish Banks, Ltd. Debrief

• What strategy did you use to maximize your assets? Did your strategy change at any point during the game? If so, how, and why did you change it?

• What happened to the fish stocks? Why did it happen? Is there any way to change the outcome?

• If you were to play this game again, what would you do differently?

• How did the “criteria for success” in the game influence your strategy? Discuss how changing the criteria for success might change the outcome of the game.

• How did the number of rounds of play affect your strategy? How might your strategy have changed if you had been playing for 40 rounds? 100 rounds?

• How did the game illustrate economic principles? Economic decision-making?

• Identify at least one element of the game that did not accurately represent economic principles as we have discussed them. Describe how might making the game more ‘realistic’ in this/these respects might have changed the outcome?
Research and Communication

• Focused question – thesis development
• Data driven analysis
• Writing with precise language and description

Systems Analysis Research Paper

Systems Elements Research Approach
Gender Equality in Latin America

Girls in Primary Education

Job Equality

Political Power

Teen Pregnancy

Marriage under 18

(UNICEF, 2005, pg. 14)

(Rutgers, Connecticut, 2005, pg. 11)

Gender-based childcare needs a case study approach (as a way to challenge traditional gender roles)
Women in Parliament

Costa Rica
Argentina
Cuba
Peru
Guatemala
Dominican Republic
Chile
Brazil
Haiti
Columbia

1995 2000 2005 2010
14 13 15
Female Unemployment Rates, 1993-2003
in Latin America

Deforestation in the Amazon

Causal Loop
Brazilian Amazon Deforestation

Brazil GDP → s → #km of paved roads

Cattle (for export) → s → rate of Brazilian Amazon deforestation

Rate of Brazilian Amazon deforestation → s → Brazil GDP
Student Reflection

Another big thing I learned was systems thinking and archetypes. This has been important because thinking of situations in terms of systems and feedback loops allows me to very quickly gain a deeper understanding of how problems actually manifest themselves, instead of focusing on one part of an issue. The archetypes also give me a quick reference point and solutions through which I can understand many different problems. For example, when I think about how all the cups are gone in the dining hall, I think of the "tragedy of the commons" archetype, and possible solutions for the problem: privatization of the commons (which doesn't really work), and I see rule-beating archetypes all over the place. These skills will allow me to be more informed politically; instead of taking a complex issue and taking an ignorant, one-sided stance on it ("we should never go to war ever!" or "let's just forbid the use of the Amazon rainforest; that will solve everything"), I can see complexities of systems behavior and hopefully come up with better solutions that address real needs.
Thinking in systems was important to me because it enhanced and put into practice the idea that there are more ways than one in which to look at a system. It made me look at things from much more than one perspective; looking at the elements, seeing feedback loops and using leverage points to change the system. The encouragement to look at the bigger picture worked very well. It helped me step back and look at larger issues that affected the little ones. Knowing how to look at things from all sides is a skill that has come in very handy here at school-action projects and dorm life come to mind—and one I know will be extremely useful in the future.
Student Reflection

Suddenly every action I do has some effect on a multitude of systems, the system of my mind and my body, the system of my local community, the system of my nation, and the system of my world.

And how? How goes back to the systems. How to look at the system and notice what to fix. Learning how to look at deforestation in the Amazon teaches me that the answer isn’t to put a bumper sticker on my car but that the answer involves massive changes in the collective consciousness of the developed world about how we consume beef. Or that being able to eat farm food in the cafeteria means watering the seedlings on the weekends and getting the whole student body involved, so everyone can be personally invested in the food that they eat, to cultivate caring about the food they eat, so they might volunteer to water the seedlings on the weekends when I am gone.
Questions? Comments?
MDGs Systems Thinking Project

Each of the MDGs you have chosen are embedded within various systems that influence their continued existence as problems and the solutions that may be effective. Your job in this project is to take a deeper look at the system in which your MDG is embedded, and to try to understand and diagram the influences and feedback loops within your system.

**Timeline:**
- October 28th – Check-in meeting with Josh or Torrey – Systems Analysis chart draft due
- October 31 – Draft BOTGs and causal loops due
- November 7 – Full project draft due
- November 18th – Final project due, including personal contact logs/emails and peer collaborative worker assessments

This is a big project that will demand a lot of time and organization from your group. Be sure you get started on this ASAP. Finding the data and information you need may be difficult, and piecing together what you can find will require a lot of thought and probably some creativity. In order to make sure you are on the right track and finding what you need, each of you must meet with either Josh or Torrey at least 2 times between now and **when the project is due to discuss your project.** The first of these meetings is scheduled for class time on October 28th. Your group should schedule a second meeting with either Josh or Torrey between then and the due date of the project.

A word of warning... We will be continuing with other work and topics in class while you work on this project. You will need to balance work on this and other assignments for the class. Doing small bits of work on this project all along the way will be important to completing it on time.

**The Task:**
This project will have 2 parts to it – a series of graphs and a causal loop diagram, and a paper describing the system you are diagramming.

**Part I: Diagramming the system:** You will be drawing both behavior-over-time graphs and causal loop diagrams for your system.

a) Through your on-going research, identify between 5 and 10 elements in your system that “drive” the system dynamics. In other words, identify those factors that make your system behave the way it does. Fill in the “Systems Analysis – A research based approach” chart for each of your elements.

b) Choose the five elements that you believe, based on your research, to be the most influential elements in the system. Using data that you have gathered, or descriptive information from your research, draw a behavior-over-time graph for each of these elements. In many cases, you will not be able to find specific data relating to your system. You will have to piece together what information you can find and use your imagination in conjunction with the information to draw these graphs. You should, however, be able explain why you have drawn the graph the way you have, using supporting evidence from your research. Be sure to refer to the “Tips for Behavior Over Time Graphs” handout to remind yourself of key elements of BOTGs. Be sure to consider what an appropriate time horizon is for your BOTGs.

c) Draw a causal loop diagram that shows how you think the system works. You should begin by drawing simple loops, and later work to connect them. Be sure to define your variables clearly. Refer to the handout “Tips for Causal Loops” to remind you of important elements of a causal loop diagram and how to get started. Identify balancing and reinforcing loops. Again, your diagram should be supported by the research
you do. You should be able to justify and explain why you have connected particular elements in the ways you have.

**Part II: Describing the system:** This portion of the assignment will be a 5-6 page paper, including several specific sections. Your writing should be based on research, and as such, should include citations and specific evidence to back up your thinking.

a) **The 40,000 foot view:** Using the skills of a systems thinker, paint the picture of your system from the 40,000 foot view. What is the big picture of what is going on? What are the major elements and forces in your system? How do they interact with one another? How do experts in the field see and understand the system?

b) **Behavior over time:** Describe how the major elements of your system have behaved over time. Do they rise and fall in a boom and bust cycle? Have they grown exponentially, or showed a steady, linear decrease over time? What are the trends in the system? What evidence can you provide that they are behaving in the way you describe?

c) **System interactions:** Describe how the elements of your system interact and influence one another. What is going on in your causal loop diagram? What leads you to believe this is how the system works? Include evidence from your research here to back up the mental model of your system that you are presenting in the causal loop diagram. Are there any unintended consequences that appear in your system? Are there unexpected interactions that were initially hidden to you? This is the place to explore and explain all of these relationships.

d) **Leverage points:** Identify and discuss 3 potential leverage points in your system that would change its behavior to help address the MDG on which you are working. Describe the kind/level of each leverage point (according to the Meadows article), and how you think your proposed change would alter the system dynamics. Draw on our discussions and readings about systems, sustainability, and the MDGs as you address this question. These leverage points can be ones that you come up with on your own, or ones that others have suggested (cite these, of course).

**Works Cited:** You should make in-text citations in your paper, and include a complete list of works cited. You should build this list starting from the 5 sources that the MDG poster groups created, but your research will most certainly need to go beyond this. **Your sources should include at least one personal contact, either by phone or email.** At the end of your paper, you should attach a summary of the conversations you had with the people on the “Personal Contact Log” sheet attached to this assignment or include a copy of email exchanges with the person.

**Assessment:** You will be assessed all six learning outcomes.

**Self-directed learner:**
- Did you complete all elements of the assignment as instructed?
- Did you make effective use of in-class and homework time to progress on the assignment?
- Did you seek help early on if needed?
- Did you turn all work in on-time?
- Did you challenge yourself to do your best work and extend beyond the basics of the project assignment?
Collaborative Worker:
Your collaborative worker score will be determined both by Josh and Torrey and by peer assessments of your contributions to the project. Please complete the peer assessment forms at the end of this assignment sheet and turn them in at the end of F block on Tuesday (after the presentations are done you will have a few minutes in class to complete these).

- Did you contribute your fair share to the work of the project?
- Did you attend group meetings and maintain a productive and helpful attitude?
- Did you contribute ideas?
- Did you listen actively to your peers?
- Did you hold yourself to a high standard for both the process of the project, as well as the product, working patiently with your peers?

Knowledgeable Person:
- Does your writing and system analysis demonstrate a solid understanding of the underlying issues and system elements of your MDG?
- Do you use the language and notation of systems thinking accurately?

Effective Communicator:
- Is your writing and analysis well organized and easy to interpret? Does the writing flow? Did you use topic sentences and supporting details in your paragraph structure?
- Did you use formatting to help guide the reader through the organization of your paper?
- Did you use correct grammar and spelling?
- Do your BOTGs have proper labels on the axes and titles on them?
- Did you include a Works Cited list and in-text citations in the proper format? Did you cite any images that are not your own?

Information Processor:
- Did you select reliable and useful resources for your resource list?
- Did you draw from a variety of information sources, detecting potential bias and cross-checking facts and theories?

Complex Thinker:
- Did you use data or research-based information to construct your BOTGs and causal loop diagrams?
- Where data was missing, did you make reasonable estimations/assumptions about system behavior, backing them up with any available information, or explaining your thinking clearly?
- Did you effectively piece together system elements into a reasonable description and diagram of system behavior?
- Did you identify potential leverage points in the system and explain why they might be effective and what the potential change would be if applied?
Personal Contact Log

Date of contact: ________________________________

Name of person contacted: ________________________________

Title or position held by person contacted: ________________________________

Phone number/email address: ________________________________

Why the person is relevant to your topic:

Questions you plan to ask:

Summary of conversation:
Recommended reading/sources of information:

Recommended contacts (including name, position/title, who they work for, why potentially relevant, and contact information):

Follow-up needed:
Peer Collaborative Worker Assessment

Group member 1 – name: ________________________________

What did this person contribute to the project? Please be specific.

Did this person meet in-group deadlines and attend group meetings? Was he/she a productive group member in meetings?

What strengths did this person have in his/her group participation/interactions?

What suggestions would you make to this person to improve his/her group work?

Circle one of the following describing overall collaborative work demonstrated by this group member on this project.
Exemplary Proficient Emerging Competency Significant Gaps Failure

Group member 2 – name: ________________________________

What did this person contribute to the project? Please be specific.

Did this person meet in-group deadlines and attend group meetings? Was he/she a productive group member in meetings?

What strengths did this person have in his/her group participation/interactions?

What suggestions would you make to this person to improve his/her group work?

Circle one of the following describing overall collaborative work demonstrated by this group member on this project.
Exemplary Proficient Emerging Competency Significant Gaps Failure
**Group member 3 – name:** ________________________________

What did this person contribute to the project? Please be specific.

Did this person meet in-group deadlines and attend group meetings? Was he/she a productive group member in meetings?

What strengths did this person have in his/her group participation/interactions?

What suggestions would you make to this person to improve his/her group work?

Circle one of the following describing overall collaborative work demonstrated by this group member on this project.
Exemplary  Proficient  Emerging Competency  Significant Gaps  Failure
**Systems Elements - Developing a Research-Based Approach**

1. System you are studying:

2. At what scale are you considering your system?

3. As you identify the key elements in your system, fill in the chart below. This is intended to help you base your list on research and not on intuition.

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<th>Element name</th>
<th>Element definition, including metric</th>
<th>Description of how element has behaved over time and citations to verify your description (be as specific as possible with your citations so you can find the data again)</th>
<th>Causal interactions with citations to verify the interaction you are describing (be as specific as possible with your citations so you can find the data again)</th>
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