Introduction to Systems Thinking

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IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

E2020
SCHOLARS PROGRAM

Our systems thinking module is…

Broadly applicable

New for students

Amenable to short treatments

Fun

NASA, tmlights.com, antfram.wikia.com, Wikimedia

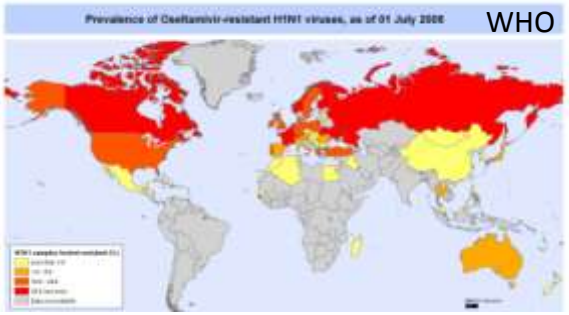
Motivation

Abundant clean water

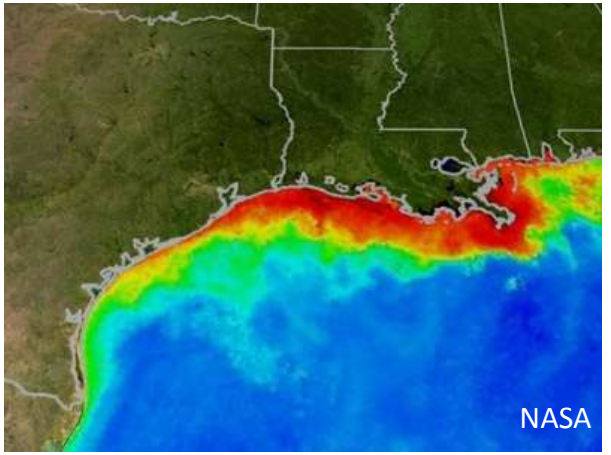
Safe roads and bridges

Protection from disasters

Renewable clean energy



Access to modern healthcare



Sustainable ag & manufacturing

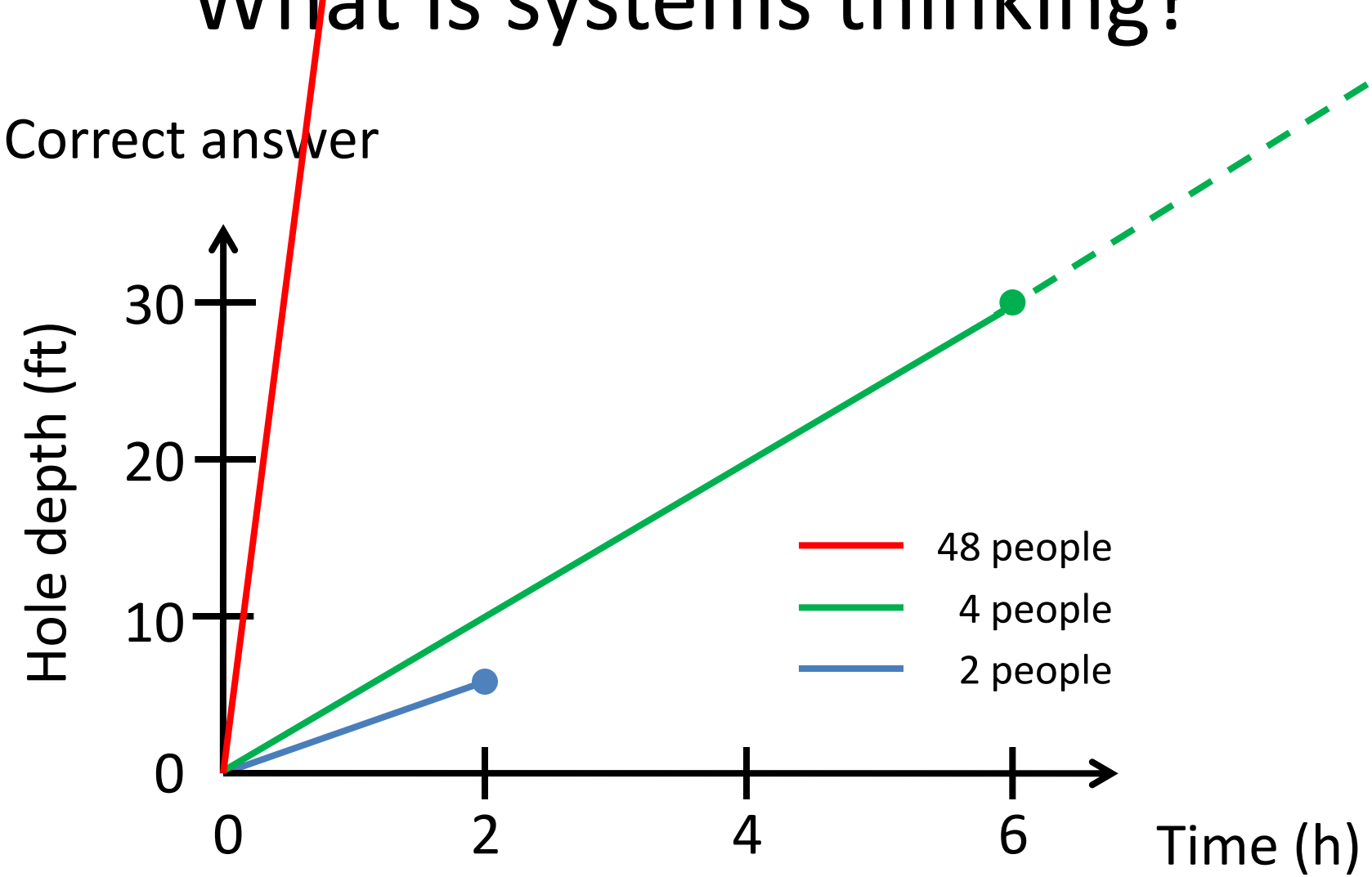
What is systems thinking?

<u>Exercise</u>

Two people take 2 hours to dig a hole 5 feet deep.

How deep would the hole be if 4 people dug for 6 hours?

What is systems thinking?



What is systems thinking?

More realistic answers?

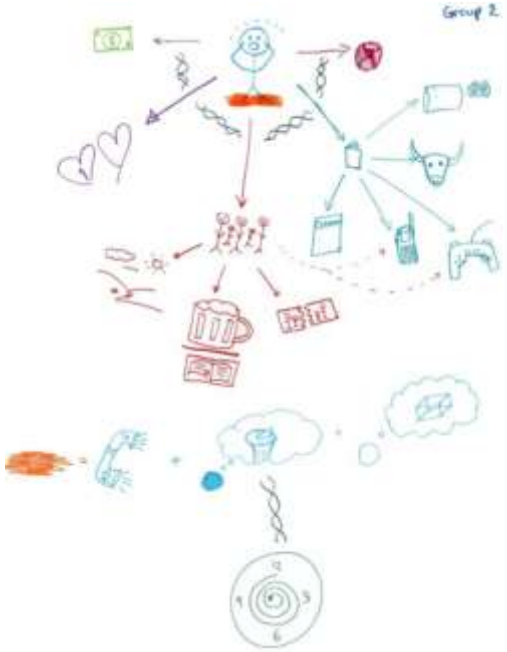
1. Deeper soil layers might be harder to excavate.
2. The job might not have the proper permit.
3. The people might refuse to work for 6 hours straight.
4. A lack of ladders or shovels or space might prevent progress.
5. They might hit bedrock or the water table (or gold or oil or ancient relics or an underground cable or vicious carnivores).
6. The maximum depth might have been specified as 5 feet.
7. Greenpeace or the neighbors might protest.
8. The workers might not have proper training in ABET outcome d.
9. The work might be scheduled for a religious holiday.
10. The original workers might have had excavating equipment.
11. Et cetera

What is systems thinking?

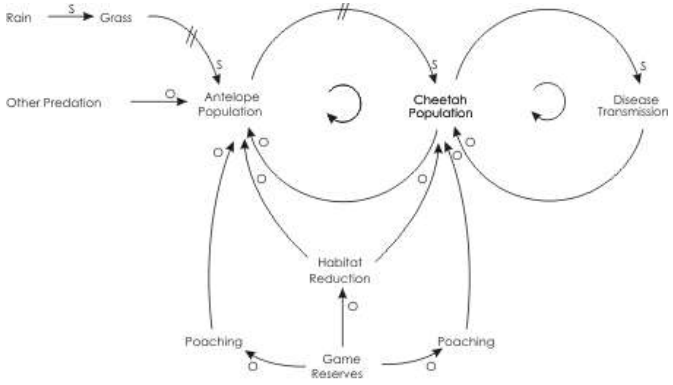
- Solving complex, dynamic, ill-defined problems
- Designing systems as well as components
- Communicating with the wider community
- Working with people from other disciplines and cultures
- Meeting social, ethical, and environmental responsibilities while addressing challenges from engineering and science.
- Managing projects and operating within business and political environments

See also http://www.public.iastate.edu/~rehmann/STpaper.pdf

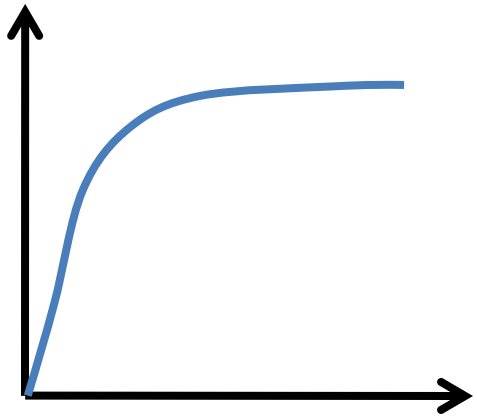
Tools of systems thinking



Rich picture



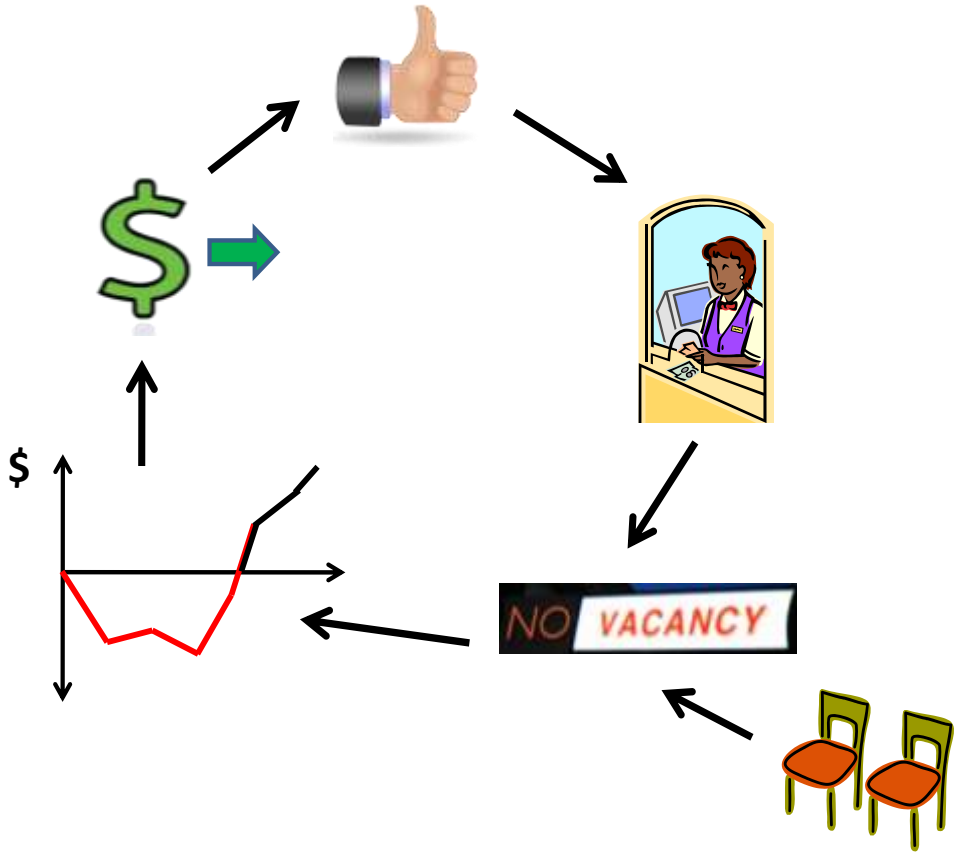
Causal loop diagrams



Behavior-over-time graphs

Example of the tools: rich picture

Theater operations

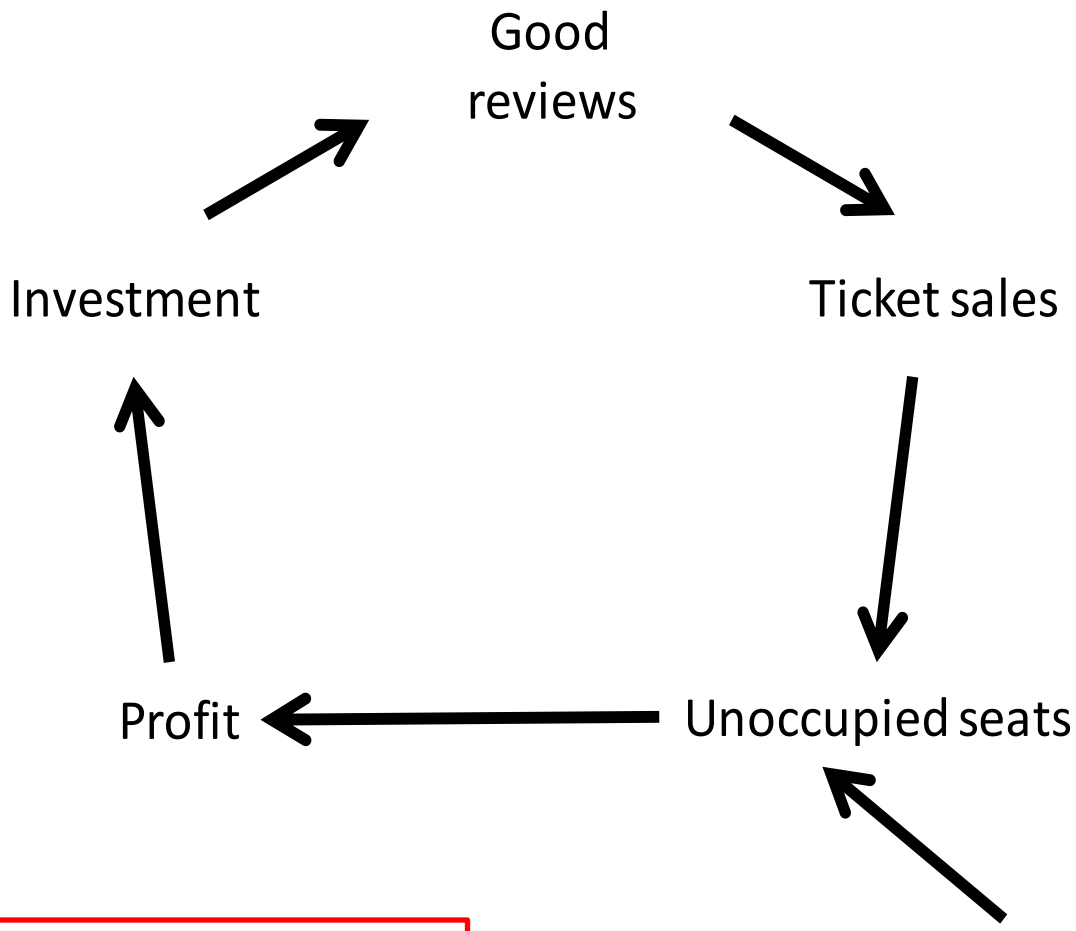


Identify connections

Example from [MindTools]

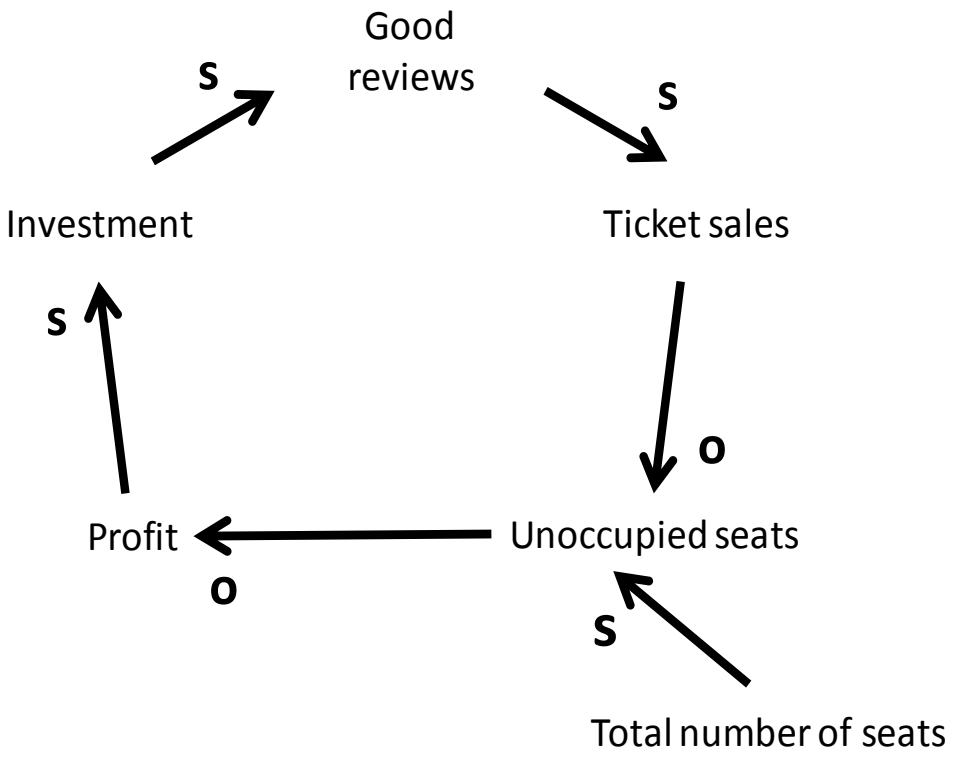
Example of the tools: causal loop diagram

s = same, o = opposite

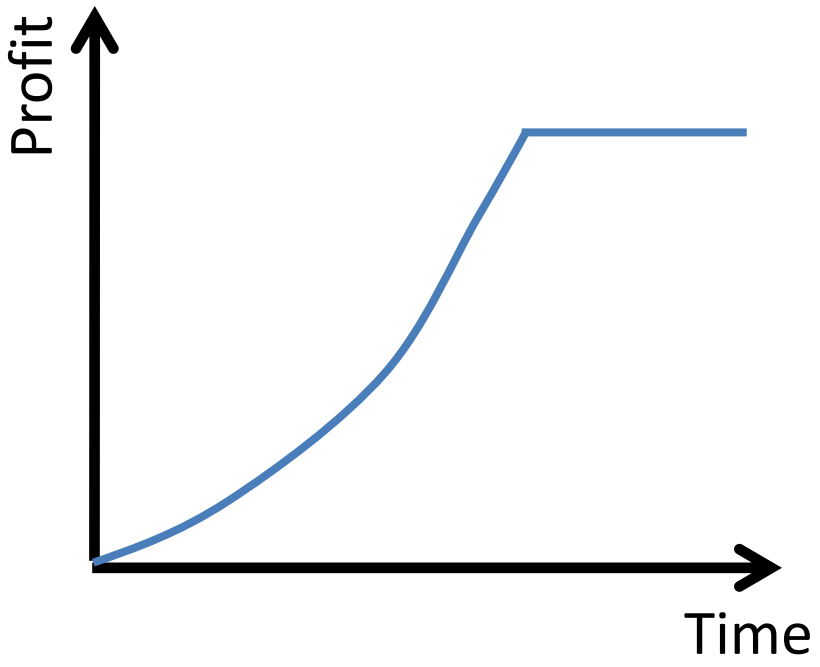


Explain relationships

Example of the tools: behavior-over-time graph



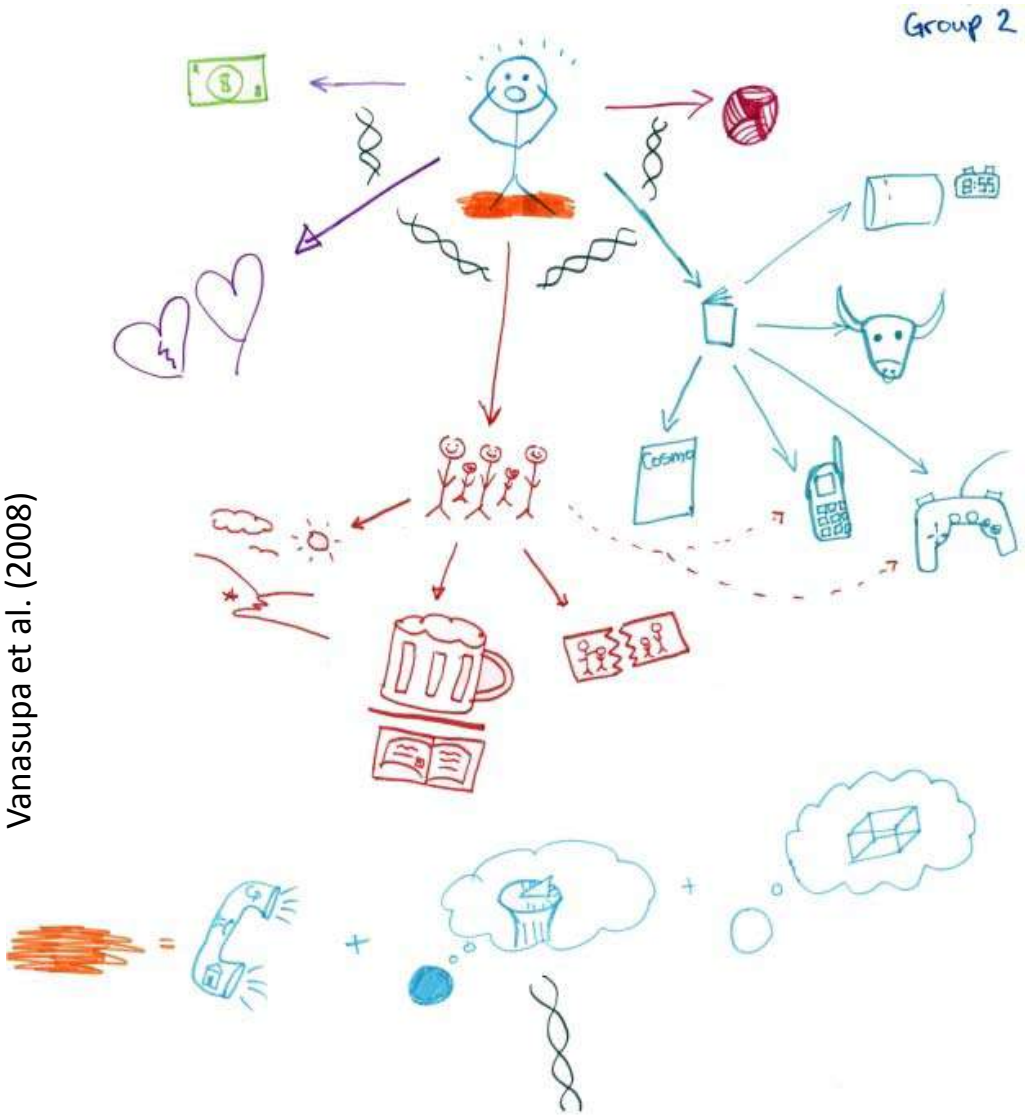
Nonlinear, feedback



Sketch trends

(Video)

http://www.youtube.com/watch?v=J030bU51ZEM



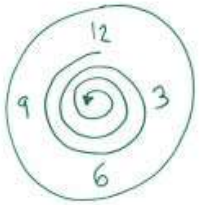
Vanasupa et al. (2008)

Rich pictures

What's going on here?

Pictures
Connections
Facts
Subjective information
Conflict
Structure
Process

Draw an unsuccessful engineering student



Exercise: Solve ISU's housing problem

KCRG

ISU is 1200 beds short.

Draw a rich picture showing the social, political, economic, environmental, cultural, ethical, and other issues related to this problem.

- How did you work together to draw the rich picture?
- How will that interaction benefit students?

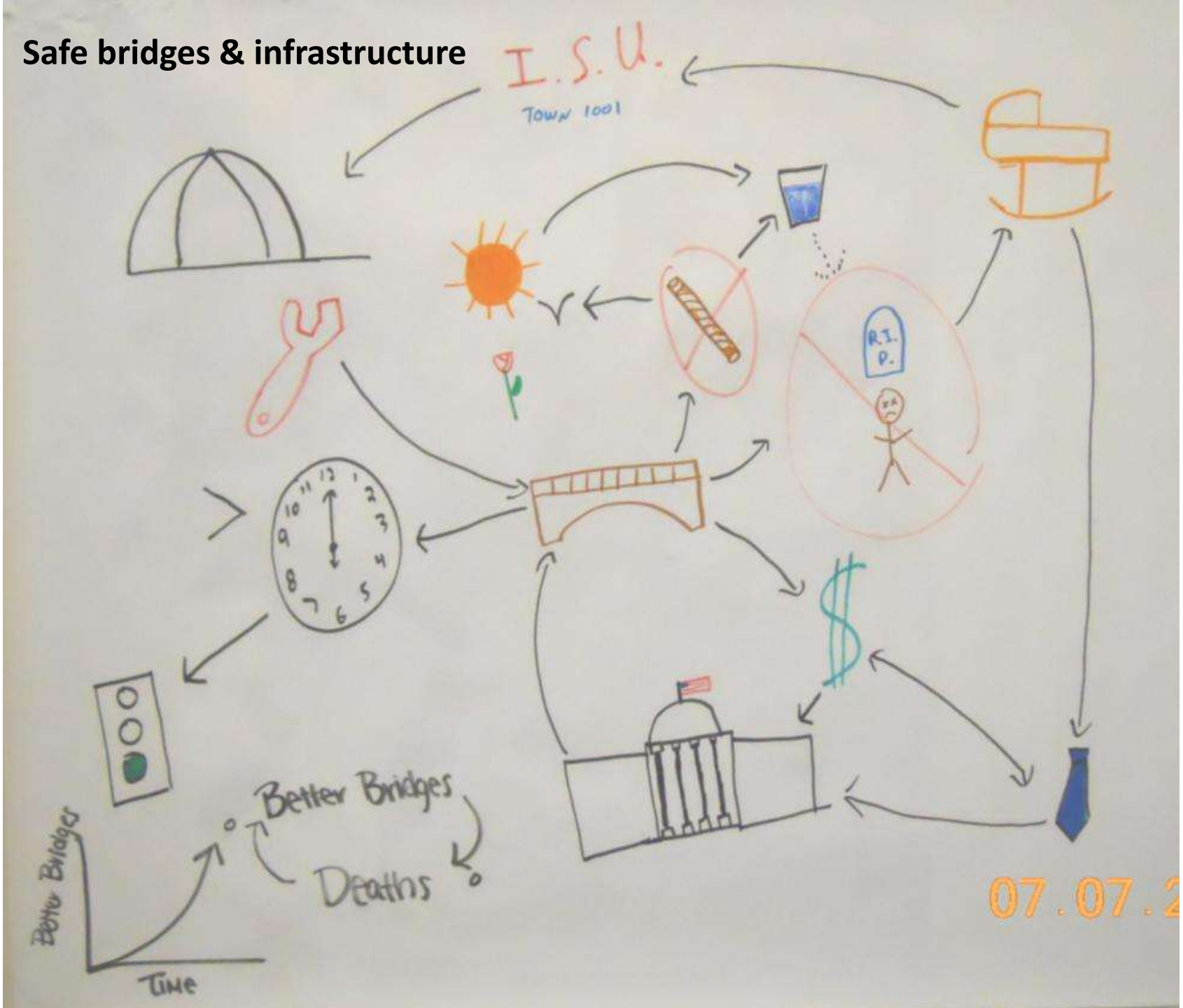
Exercise: Evaluate these rich pictures

Did they think broadly? Do the connections make sense? Is there feedback?

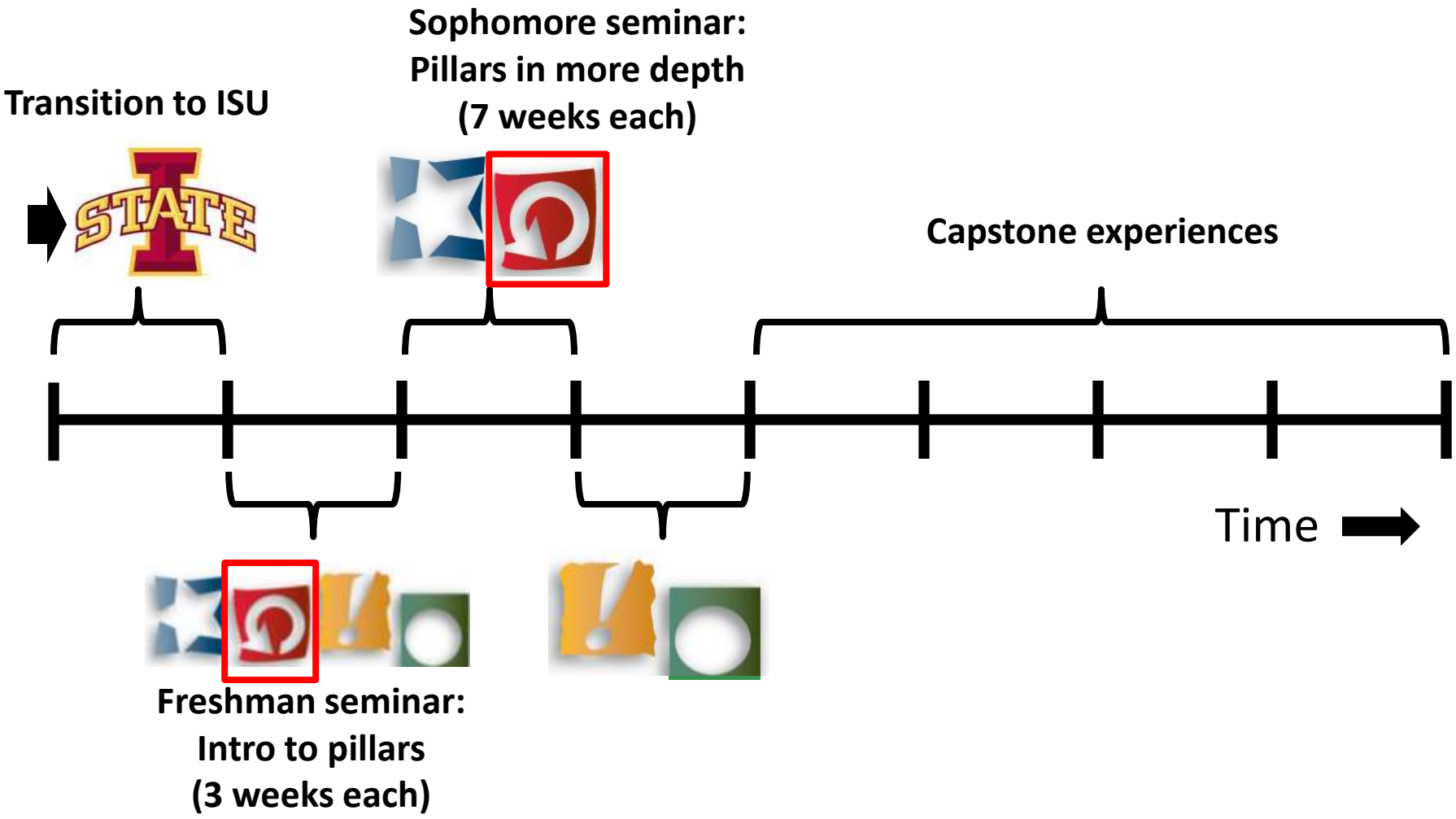
	0 = not addressed	1 = minimally addressed	2 = somewhat addressed	3 = adequately addressed	4 = well addressed
Technical content					
Problem description	Students do not describe the problem at all.	Students give a cursory description of the problem.	Students describe the problem briefly but do not explain how it involves 5 of the 7 areas.	Students describe the problem and motivate the systems approach by explaining how it involves 5 of the 7 areas.	Students explain why the problem is important and integrate their discussion of the 5 of 7 areas well into the rest of the talk.
Key variables	Students identify no key variable.	Students allude to key variables. Key variables are implied.	Students identify several variables involved in the problem but do not identify the key variable.	Students identify a key variable but other possibilities seem more fitting.	Students identify a key variable and explain concisely how it captures the essence of the problem.
Rich pictures to show connections	Students present no rich picture.	The rich picture is carelessly drawn, and the connections show little thought.	The rich picture shows few elements, and connections are merely lines drawn to the key element.	The rich picture is drawn well. It includes several elements from 5 of the 7 areas; connections show considerable thought.	The picture is attractive and interesting; the connections drawn suggest careful thought and contemplation based on research.
Causal-loop diagrams to show relationships	Students present no causal-loop diagrams.	Students present only one or two CLDs and they are not connected in any way. Relationships are based solely on intuition or feeling.	Students present several unconnected CLDs. The relationships are reasonable but not supported convincingly.	Students present a CLD that connects most of the elements in the rich picture and give plausible arguments for the relationships.	Students present a CLD that connects all of the elements in the rich picture and argue convincingly for the relationships using their research.
Graphs to show behavior over time	Students do not show behavior over time.	Students present one BOT graph that was drawn hastily and without much thought.	Students present a BOT graph and explain the behavior briefly.	Students present a BOT graph for one scenario that is carefully contemplated.	Students present BOT graphs for a few interesting scenarios. The graphs illustrate the strength of the systems thinking approach.

Increase in Iowa's gas tax

Safe bridges & infrastructure



Applications of the modules



Freshman seminar: Engr 110X

Definition of ST, intro to tools

Student work: Rich picture (& other tools)

2010

2011

2012

Week 1 | Week 2 | Week 3

Student presentations

2010

2011

2012

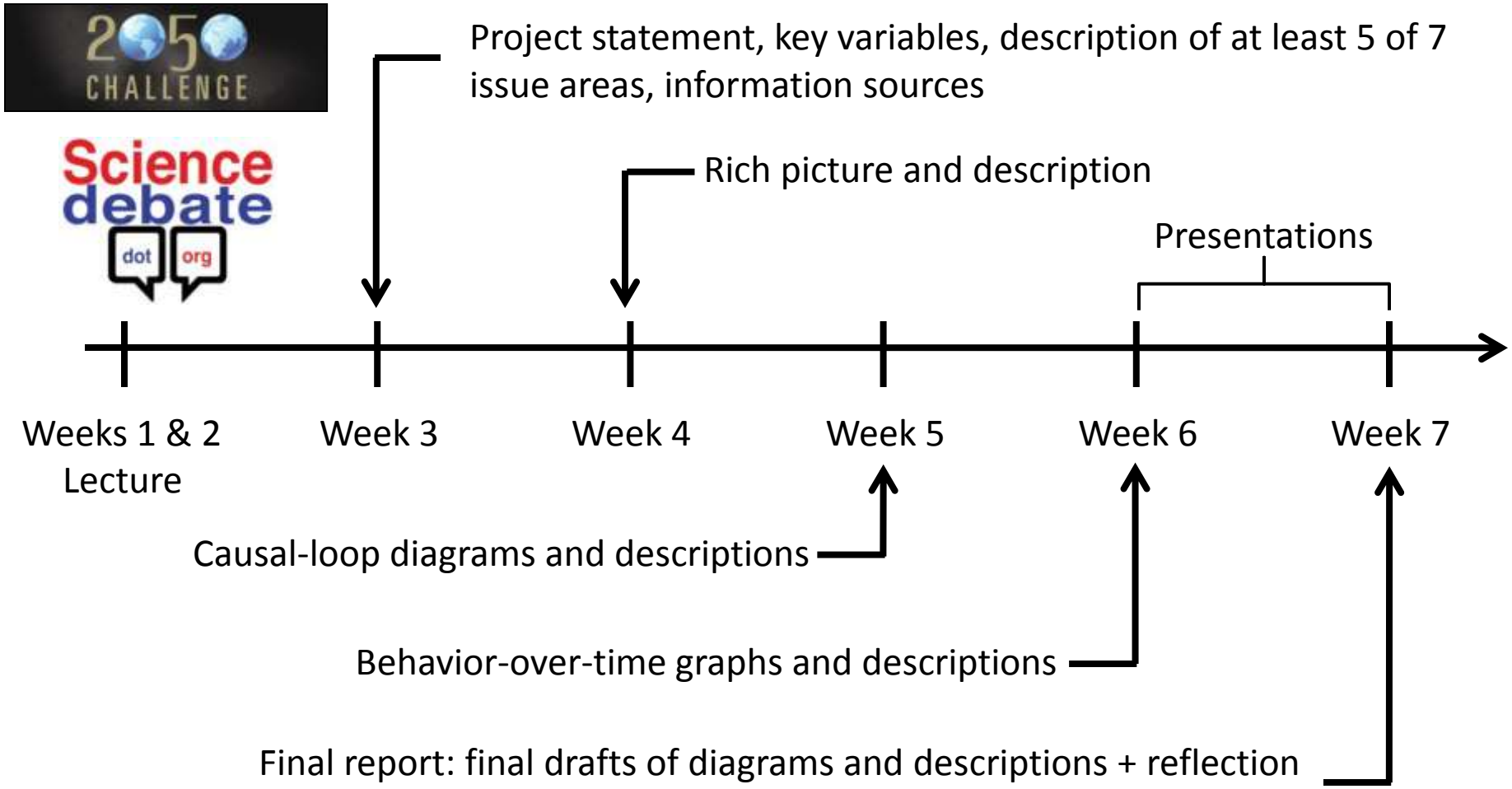
Sophomore seminar: Engr 210X

Learning outcome:

For complex, ill-defined, dynamic problems involving engineering, social, ethical, cultural, environmental, business, and political issues, second-year E2020 scholars will

- Identify connections between subsystems with rich pictures
- Explain relationships with causal-loop diagrams
- Sketch the behavior over time of key variables in the system.

Sophomore seminar: Engr 210X



Assessment

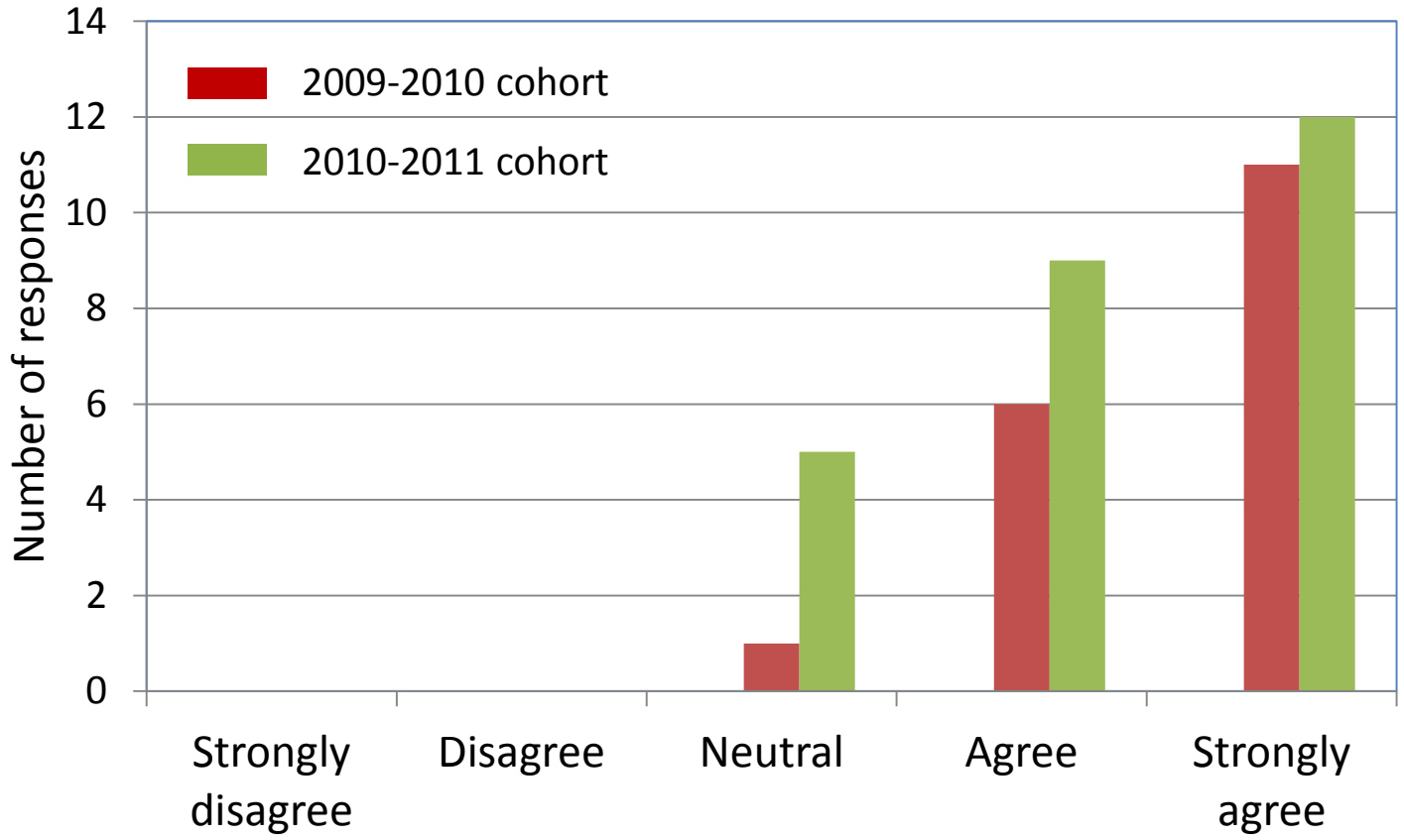
Reflections from students:

- Students knew little about ST before the module and much more after it.
- The module will help in planning projects.
- Multidisciplinary aspects will improve collaboration.
- Students appreciated having tools to express the behavior graphically.
- Students enjoyed the activities.
- The module changed how students view engineering.

Assessment

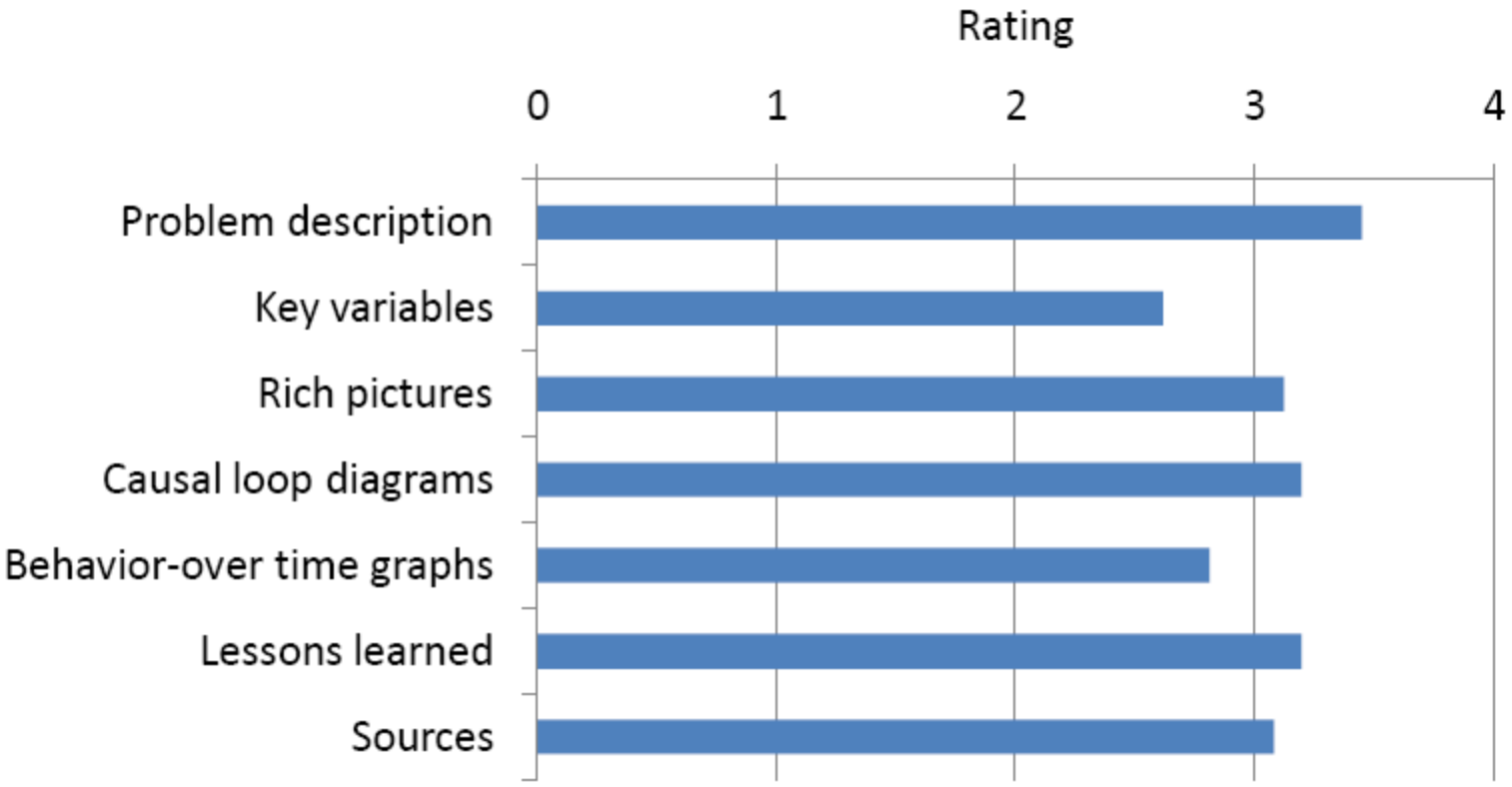
Email survey for Engr 110X:

"I have an understanding of the systems thinking pillar…"



Assessment

Ratings from 3 instructors of student work in Engr 210X



ST in LC?

Freshman orientation

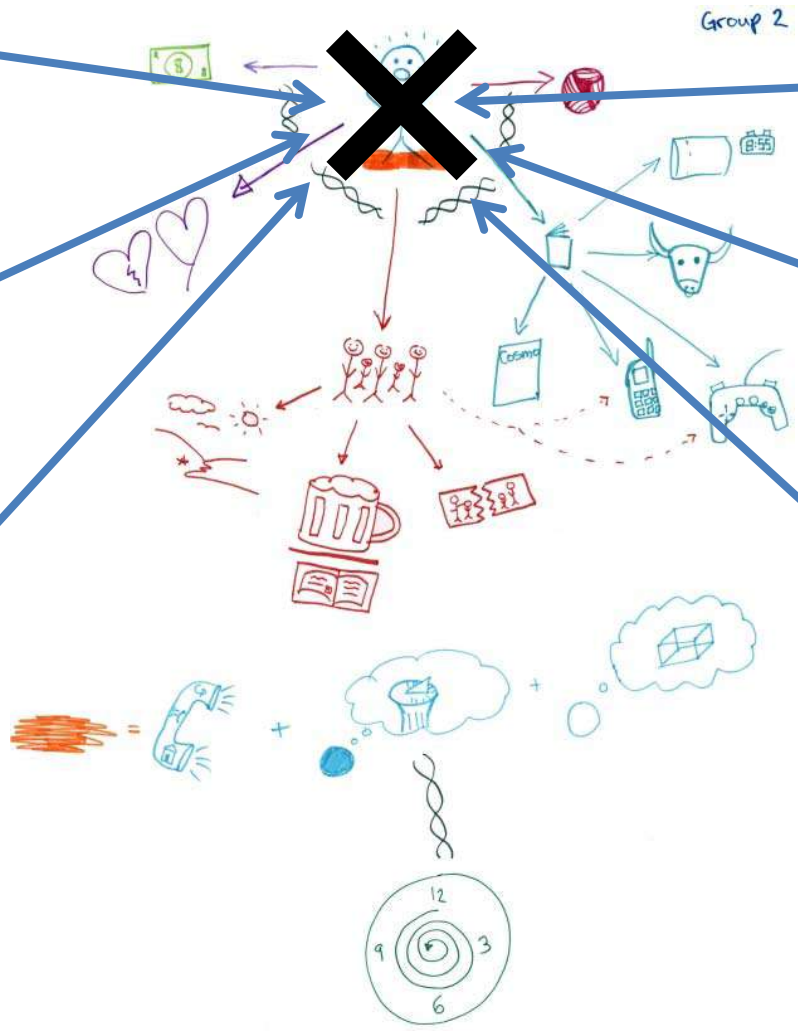
Club projects

Service learning

Homework teams

Time management

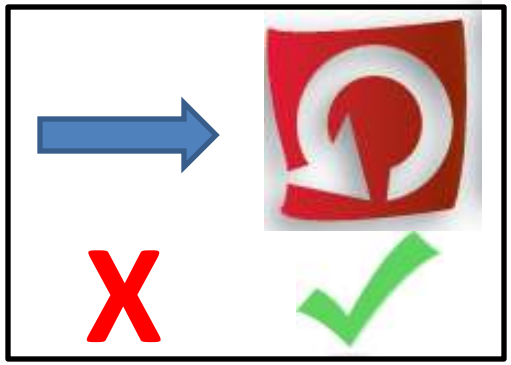
Freshman design



ST in LC?

Observations and suggestions:

1. Students tend to get information from their own heads.
    a. Coach them to find an article or two, or
    b. Use a topic that is familiar.
2. Students need coaching with key variable and feedback.



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