

Cognitive Analysis of a Systems Thinking Educational Assignment: Find & Map the Feedback Loop in Popular Media Articles

Kim Kastens

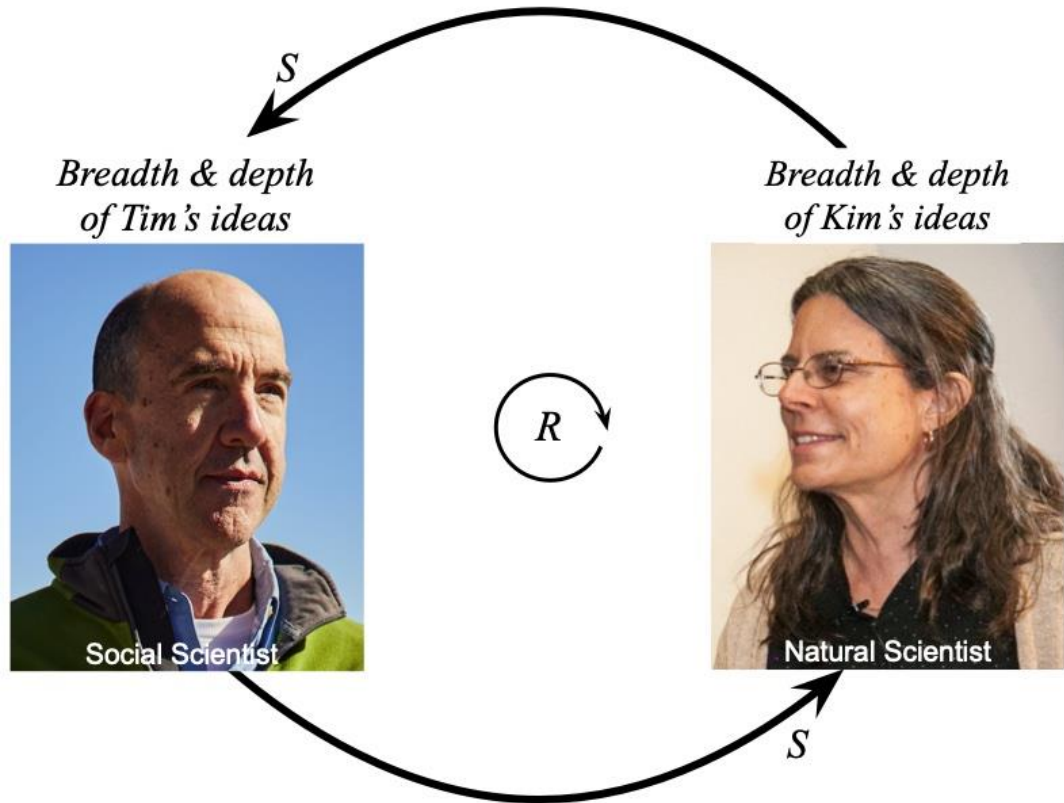
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of Columbia University

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Temple University

International Systems Dynamics Conference
Boston, August 4, 2025

National Science Foundation IUSE grants, *Supporting Feedback Loop Learning in Natural and Social Science Courses*: Kastens (2141939), Shipley (PI) & Davatzes (2142010), and Brenner (2141982).



Problem Statement:

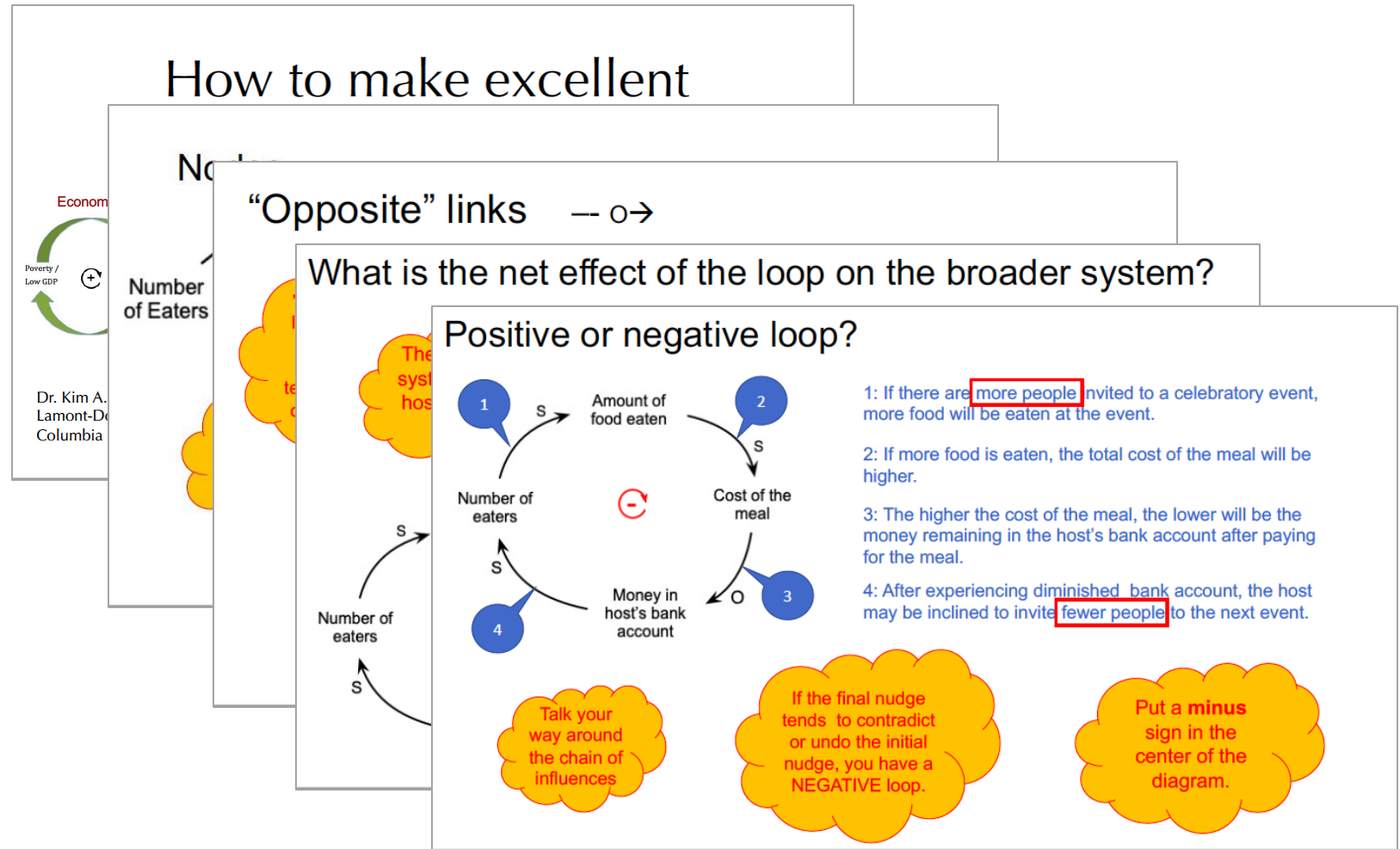
- Systems thinking draws on complex cognitive processes...
- ... but many instructors of systems thinking and systems dynamics lack expertise in cognitively-informed pedagogy...
- ... and thus may be misunderstanding their students' struggles ...
- ... or missing opportunities to build their students' strengths.

Cognitive task analysis:

The process of examining how learners process information and build understanding while completing an instructional activity.

The assignment: Find and map the feedback loop in a popular media article

Students watch an instructional video....



Then read a short reading passage ...

adapted from

Outlive: The Science and Art of Longevity

by Peter Attia and Bill Gifford (2023)

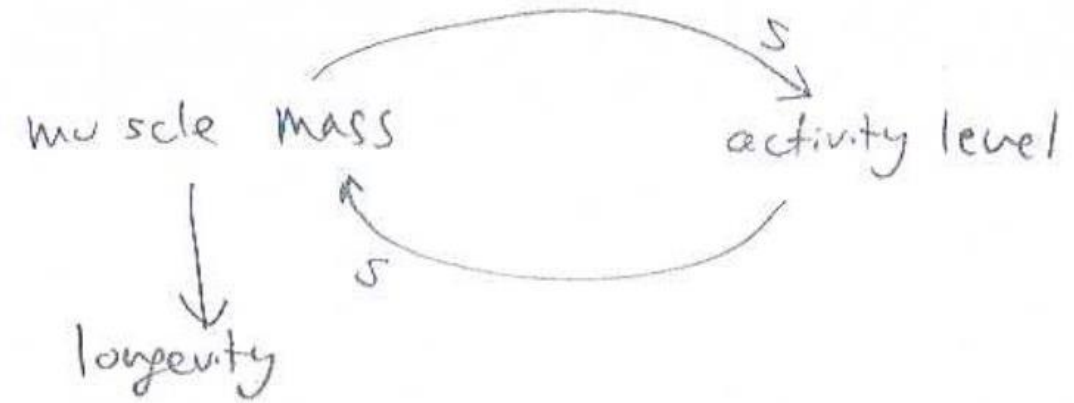
One of the prime hallmarks of aging is that our physical capacity erodes. ... We lose strength and muscle mass with each passing decade, our bones grow fragile and our joints stiffen, and our balance falters, a fact that many men and women discover the hard way, by falling off a ladder or while stepping off a curb.

To paraphrase Hemingway, this process begins in two ways: gradually and then suddenly. The reality of the situation is that old age can be really rough on our bodies. Longitudinal and cross-sectional studies find that [muscle mass] and activity levels remain relatively consistent as people age from their twenties and thirties into middle age. But both physical activity levels *and* muscle mass decline steeply after about age sixty-five, and then even more steeply after about seventy-five. It's as if people just fall off a cliff sometime in their mid-seventies.

... *two more paragraphs*

... and draw a CLD and write an accompanying narrative

1. Mark the place in the article that you think conveys a feedback loop...
2. Sketch a causal loop diagram (CLD) that depicts the feedback loop...
3. Write a narrative that describes how the loop works.
 - Your narrative should start at one node and progress all the way around the loop.
 - Your narrative should discuss the net effect of the loop taken as a whole on the larger system within which the loop is embedded.



high muscle mass makes it easier to be active. Being active builds muscle mass. More muscle mass is associated with a longer life.

		Exceeds	Meets	Room for	Unacceptable
		Meets Expectations			(1)
Nodes / Causal Relationships / Connections	(1a) Node CLD	Nodes	(1a) Nodes on the CLD	<ul style="list-style-type: none">• All nodes that are part of a loop depict something that can potentially increase or decrease, such as a quantity (<u>e.g.</u> # of people), state (e.g. anger, temperature), or attribute (e.g. strength), <i>and</i>• Nodes do not state or imply the direction of change.	
	(2a) Link the CLD				
	(2b) Narr descriptive links				
	(2c) Connection or depicted links to real-world system				
Net Effect of Loop as a Whole	(3a) Net effect of loop depicted on CLD				
	(3b) Understanding of impact of this loop on a broader system within which it is embedded.				

For details, see Kastens, Wakeland & Shipley, 2024 ISDC paper

Why we like this assignment

Life-long relevance

Any content domain

Many instructional contexts:

- Workshop
- Small-group, in class
- Homework
- Research instrument
- Course assessment

Serious cognitive challenges



Photo from Earth Educators' Rendezvous 2024. Credit: Kim Kastens

Higher order cognitive skills identified:

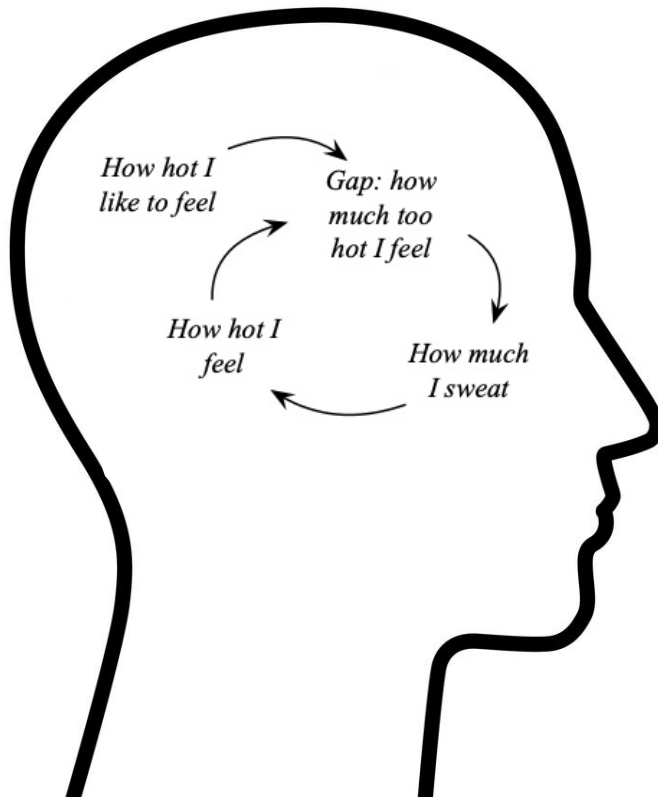
- 1) *To find the loop:* Analogical reasoning
- 2) *To make each link:* Causal reasoning
- 3) *Throughout:* Distinguishing and integrating parts and wholes
- 4) *To make the CLD:* Semiosis – making meaning with signs
- 5) *To write the narrative:* Linguistic structures for hypothetical and conditional propositions

(1) To find the loop: Analogical reasoning

Analogic reasoning: The process by which the human mind can notice important similarities between analogs, and then use those similarities to generate new inferences.

Projective analogy: Use known attributes of familiar “source” analog to better understand unfamiliar “target” analog.

SOURCE ANALOG

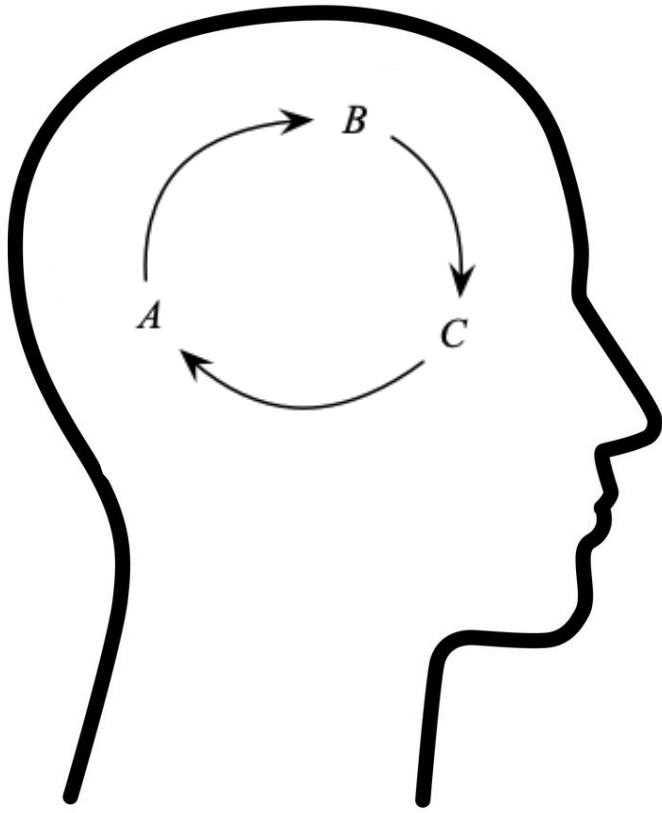


TARGET ANALOG



(1) To find the loop: Analogical reasoning

SOURCE ANALOG



TARGET ANALOG



FAR ANALOGY

(1) To find the loop: Analogical reasoning

Projective analogy: Use known attributes of familiar “source” analog to better understand unfamiliar “target” analog.



Easier, limited utility



Harder, broader utility

Progressive alignment:

1. Multiple reinforcing feedback loops all driven by the same climate nudge of changing air temperature.
2. A balancing loop driven by same climatic nudge.
3. A loop that is in a social system rather than a physical system.

(2) To create links: Causal reasoning

Under what real-world circumstances are we justified in making a claim that “A” causes or influences “B”?

Ask yourself:

- Do I have a plausible mechanism by which this “A” *should* cause or influence this “B”?
- Do I have empirical evidence that in the real world this “A” *does* reliably follow this “B”?
- Want both; often have to settle for one or the other.

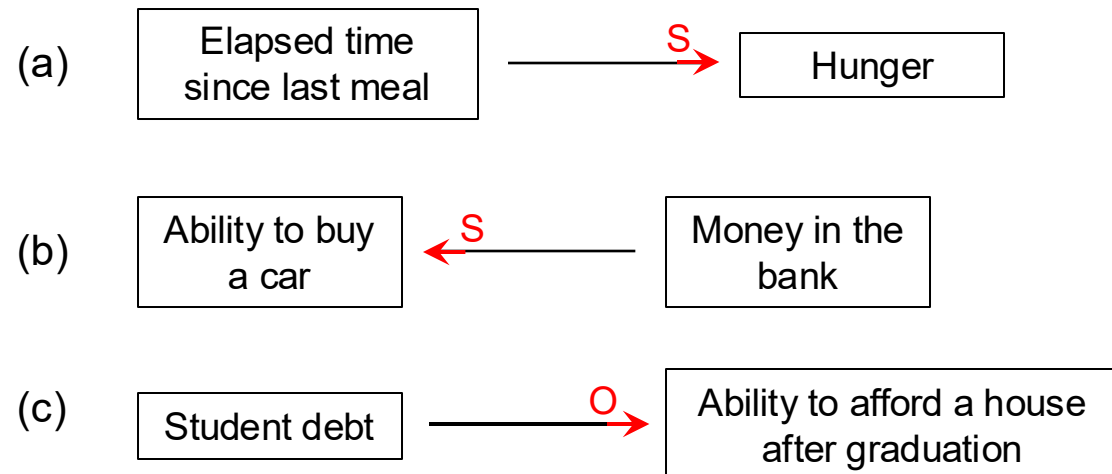
(2) To create links: Causal reasoning

For each item, indicate the type of causal link that you think connects the two boxed nodes. For each item, there are 4 possibilities:



Draw an arrow head to indicate the direction of influence.

Add a “S” to the arrow if you think two nodes change in the *Same* direction. Add an “O” to the arrow if you think that the two nodes change in the *Opposite* direction.



(3) Distinguishing & integrating parts & wholes

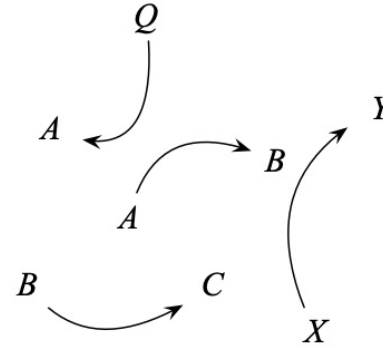
adapted from
Outlive: The Science and Art of Longevity
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One of the prime hallmarks of aging is that our physical capacity erodes. ... We lose strength and muscle mass with each passing decade, our bones grow fragile and our joints stiffen, and our balance falters, a fact that many men and women discover the hard way, by falling off a ladder or while stepping off a curb.

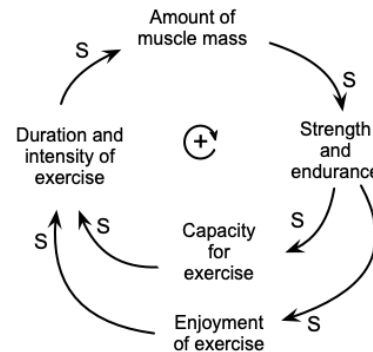
To paraphrase Hemingway, this process begins in two ways: gradually and then suddenly. The reality of the situation is that old age can be really rough on our bodies. Longitudinal and cross-sectional studies find that [muscle mass] and activity levels remain relatively consistent as people age from their twenties and thirties into middle age. But both physical activity levels and muscle mass decline steeply after about age sixty-five, and then even more steeply after about seventy-five. It's as if people just fall off a cliff sometime in their mid-seventies.

By age eighty, the average person will have lost eight kilograms of muscle or about eighteen pounds, from their peak. But people who maintain higher activity levels lose much less muscle, more like three to four kilograms on average. While it's not clear which way the causation flows here, I suspect it's probably both ways: people are less active because they are weaker, and they are weaker because they are less active.

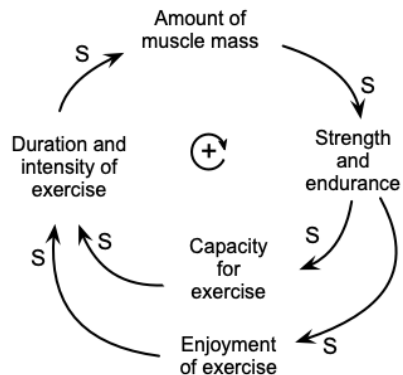
Continued muscle loss and inactivity literally puts our lives at risk. Seniors with the least muscle mass (also known as lean mass) are at the greatest risk of dying from all causes. One Chilean study looked at about one thousand men and four hundred women, with an average age of seventy-four at enrollment. The researchers divided the subjects into quartiles, based on their appendicular lean mass index (technically, the muscle mass of their extremities, arms and legs, normalized to height), and followed them over time. After twelve years, approximately 50 percent of those in the lowest quartile were dead, compared to only 20 percent of those in the highest quartile of lean mass. While we can't establish causality here, the strength and reproducibility of findings like this suggest this is more than just a correlation.



WHOLE → PART



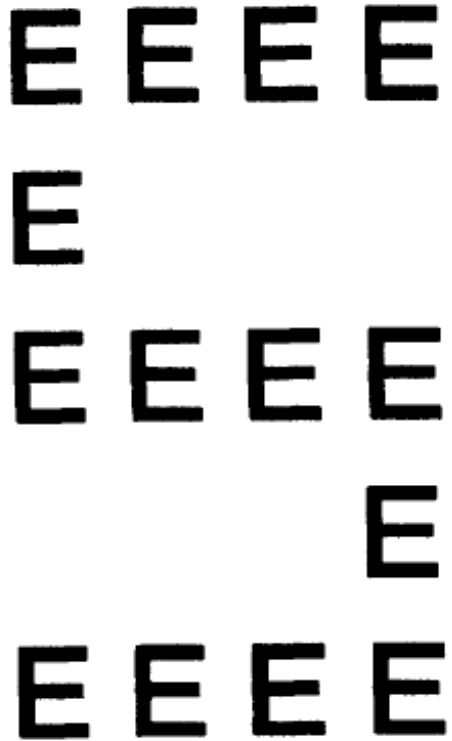
PART → WHOLE



Net effect of the loop on the larger system within which the loop is embedded.

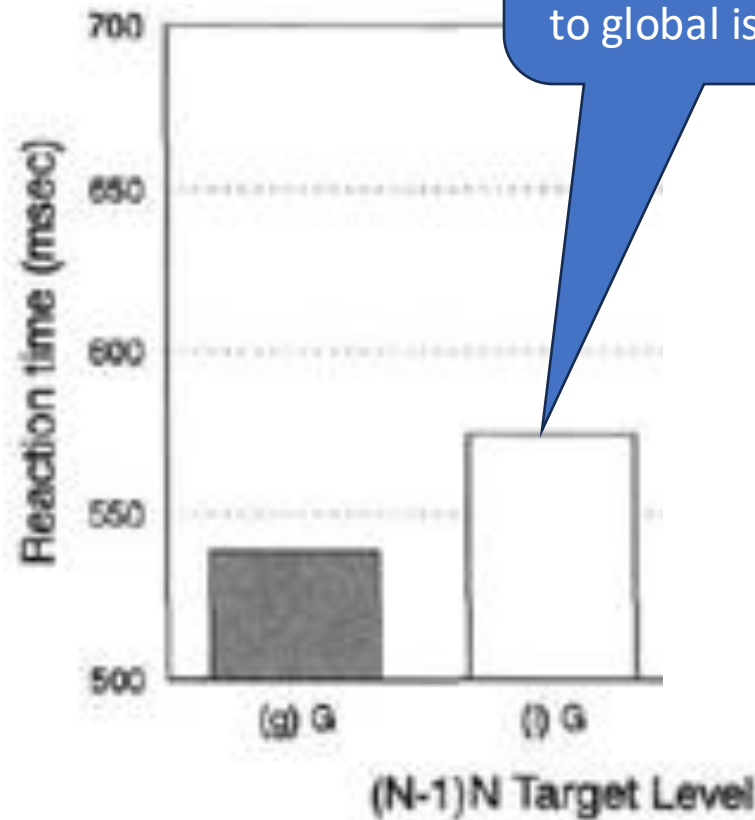
WHOLE → PART

(3) Distinguishing & integrating parts & wholes



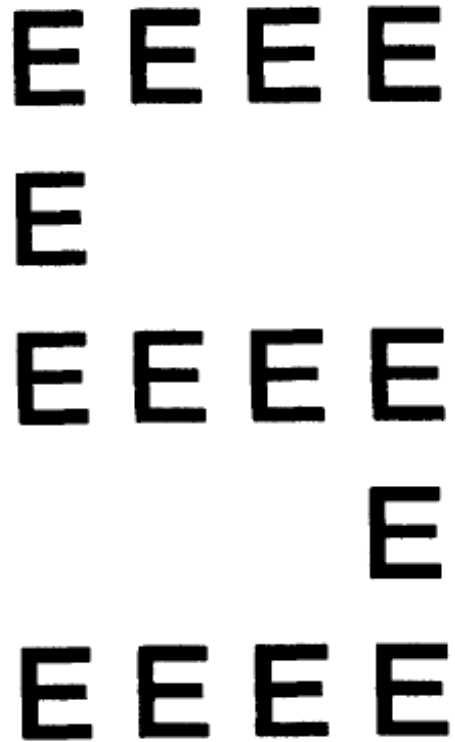
“Navon letter”

- S is global
- E is local



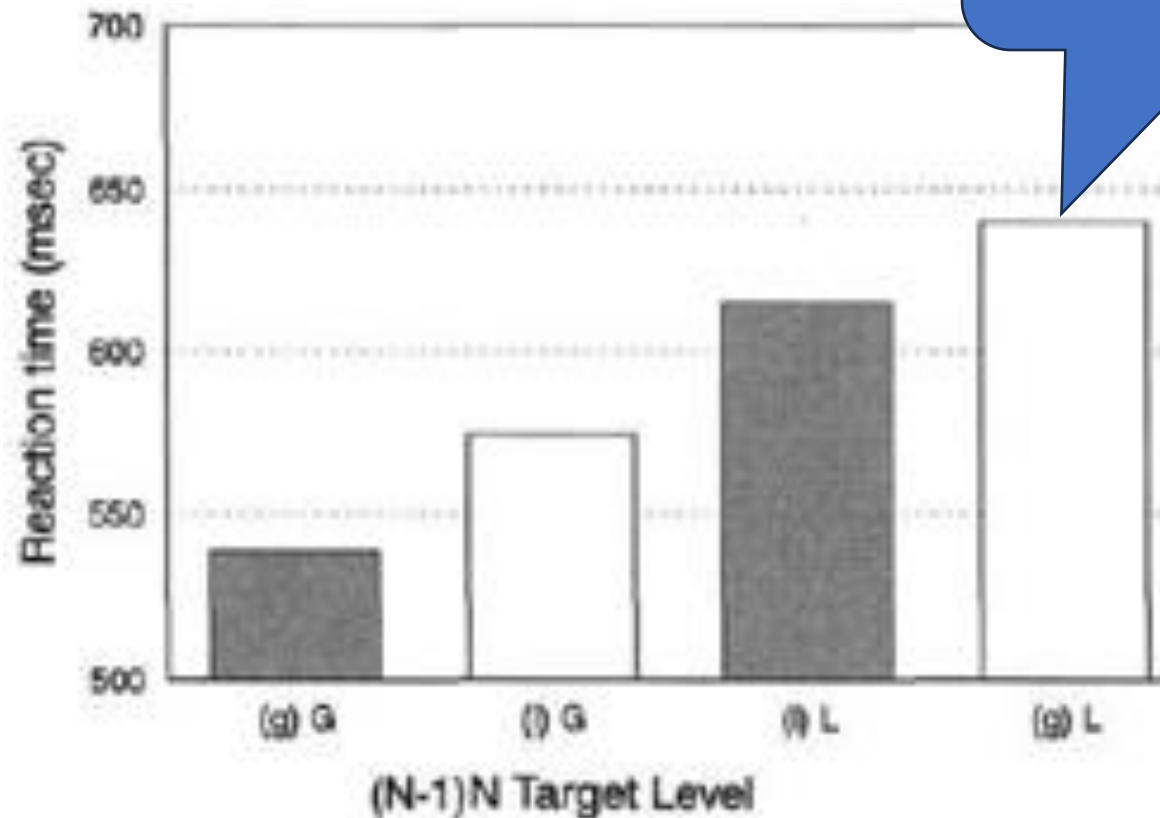
Task is harder
(slower) when
switching from local
to global is required

(3) Distinguishing & integrating parts & wholes



“Navon letter”

- S is global
- E is local



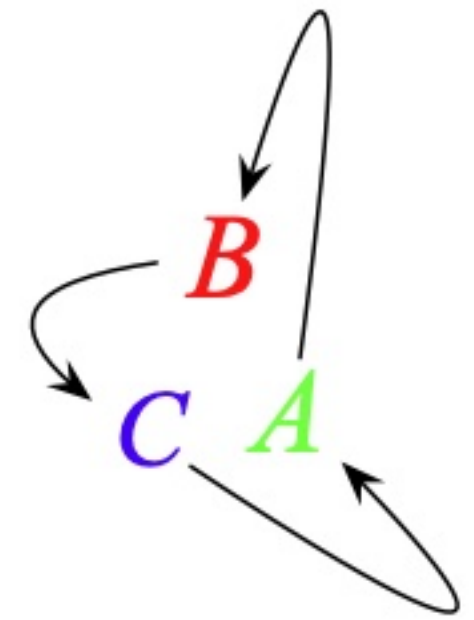
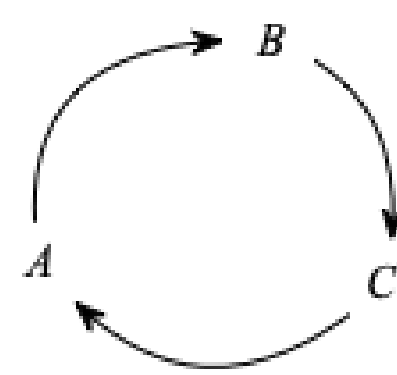
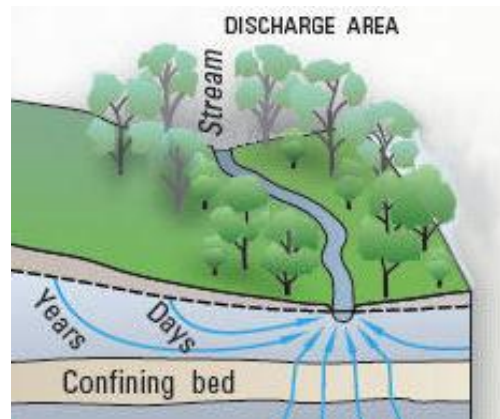
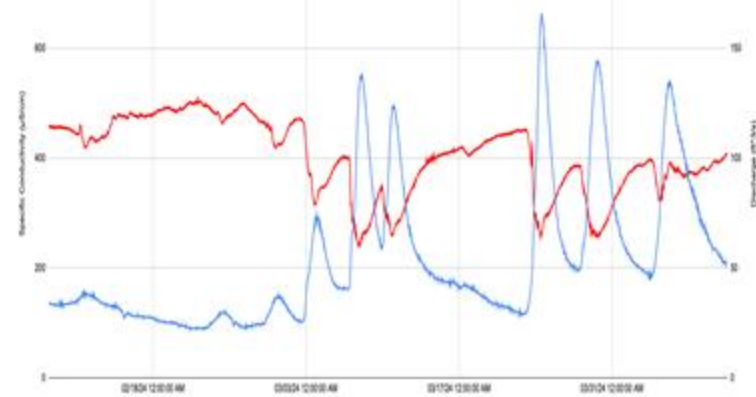
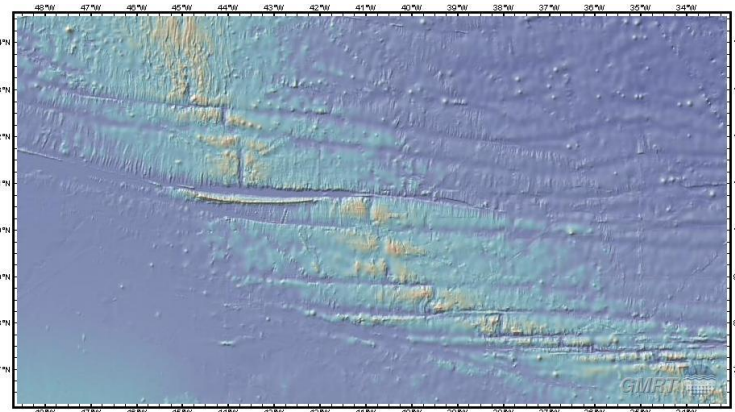
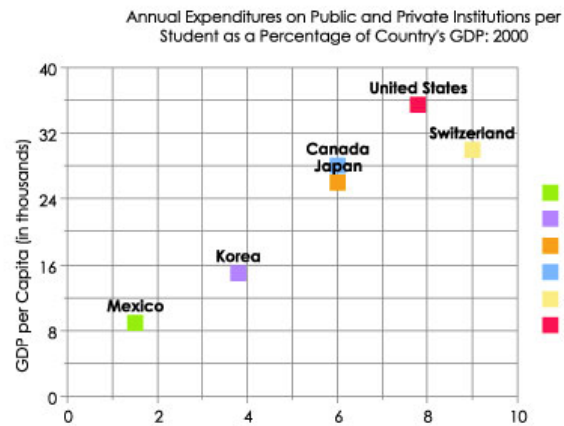
Task is hardest (slowest)
when switching from global
to local is required

(4) To make the CLD: Making meaning with signs

The use of space on the page or screen is unfamiliar

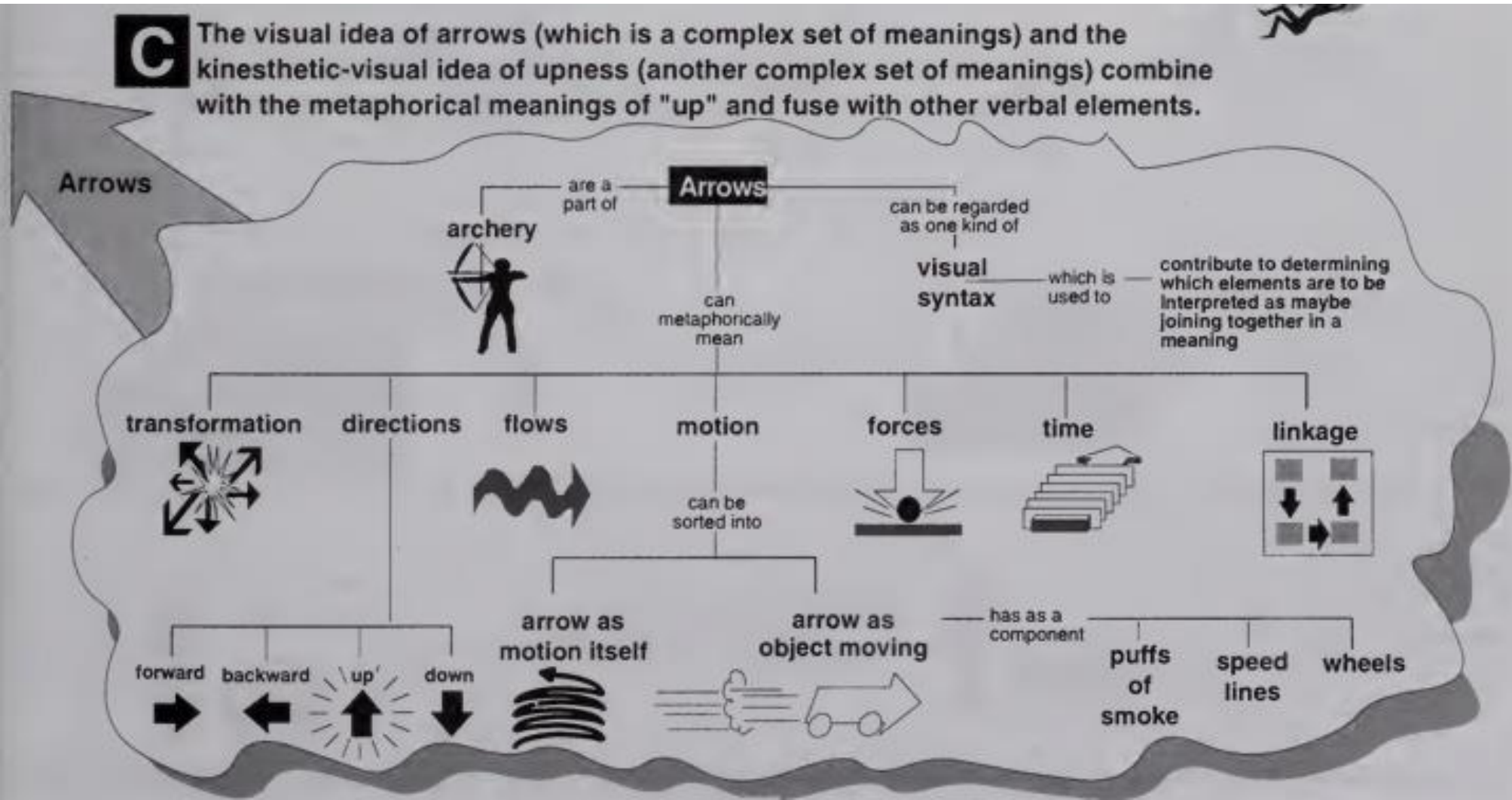
Position, distance, orientation and size are important signifiers.

Position, distance, orientation, size don't matter



(4) To make the CLD: Making meaning with signs

The graphic language is unfamiliar: what does an arrow mean?



Horn, R.E, 1998,
Visual Language.
Bambridge Island,
WA. MacroVu, Inc.

(4) To make the CLD: Making meaning with signs

What does an arrow mean?

... and therefore,
and therefore,
and therefore...

...and then,
and then, and
then...



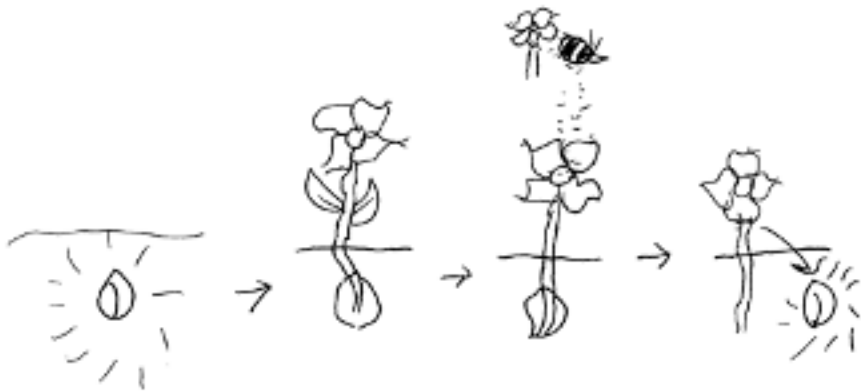
People tend to see temporal cycles as linear chains, not loops

“Please think about the following 4 stages and then construct a simple, schematic diagram conveying them”

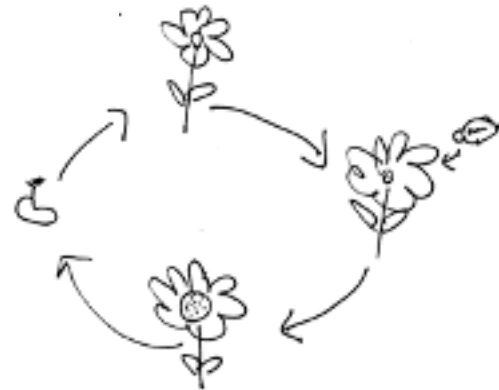
- The tree grows
 - The tree dies
 - The tree decomposes
 - Fossil fuel is formed
- The seed germinates
 - The flower grows
 - The flower is pollinated
 - A new seed is formed

(temporal sequence)

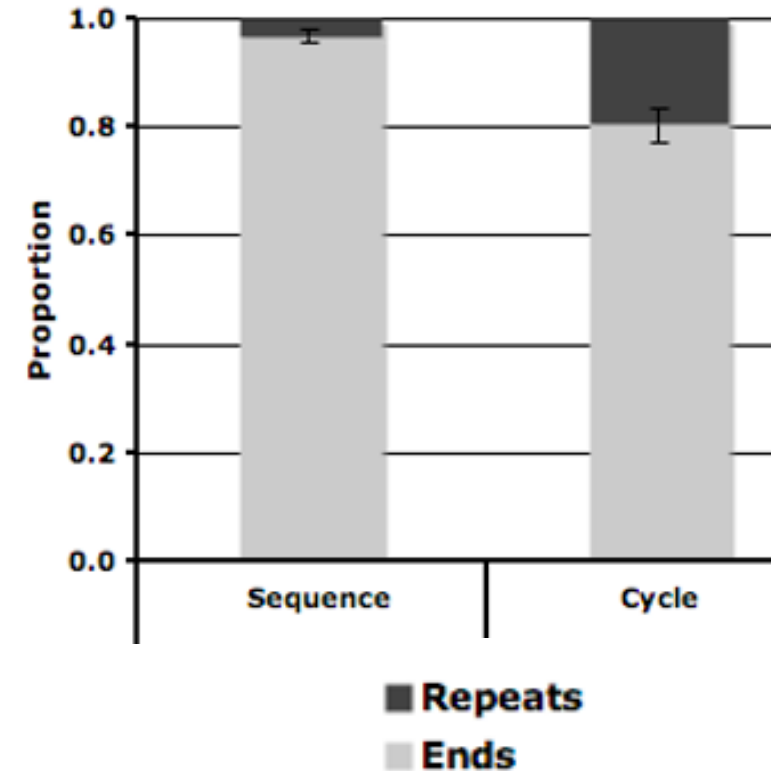
(temporal cycle)



Answer coded as “ends”



Answer coded as “repeats”



Higher order cognitive skills identified:

- 1) *To find the loop:* Analogical reasoning
- 2) *To make each link:* Causal reasoning
- 3) *Throughout:* Distinguishing and integrating parts and wholes
- 4) *To make the CLD:* Semiosis – making meaning with signs

For more of our ideas:

Fostering Feedback Loop Thinking
(Website of educational materials)



https://serc.carleton.edu/teachearth/feedback_loops/index.html

Loops Behind the News
(Substack)



<https://loopsbehindnews.substack.com>