

Thinking about Systems Thinking: How We Improve

Systems Thinking and Dynamic Modeling
Conference

Skamania, Washington, June 2004

Origins of these Ideas

- A long friendship with Barry Richmond, our most creative pedagogical thinker
- A long history of conversations with him about software, methods, and pedagogy
- A particular set of conversations we had in May 2002
- ...Leading to thoughts about stages of map and model *improvement*

Barry's Recent Pedagogical Innovations

(*An Introduction to Systems Thinking*, *isee systems*)

- A linguistic metaphor to guide model development
 - Noun-like quantities as stocks
 - Verb-like quantities as flows
 - Adverb-like quantities as modifiers of flows
- Start with *everything* being a stock or a flow and improve from there
- Subtext: Don't use word-and-arrow diagrams for conceptualization

George's Recent Pedagogical Thinking

- Early maps as “half-baked” modeling thoughts; “half-baked” is OK.
- Causal-loop diagrams sometimes essential for getting started
- A continuum from *informal* to *formal maps*
- Thinking more *operationally* enables movement along this continuum.

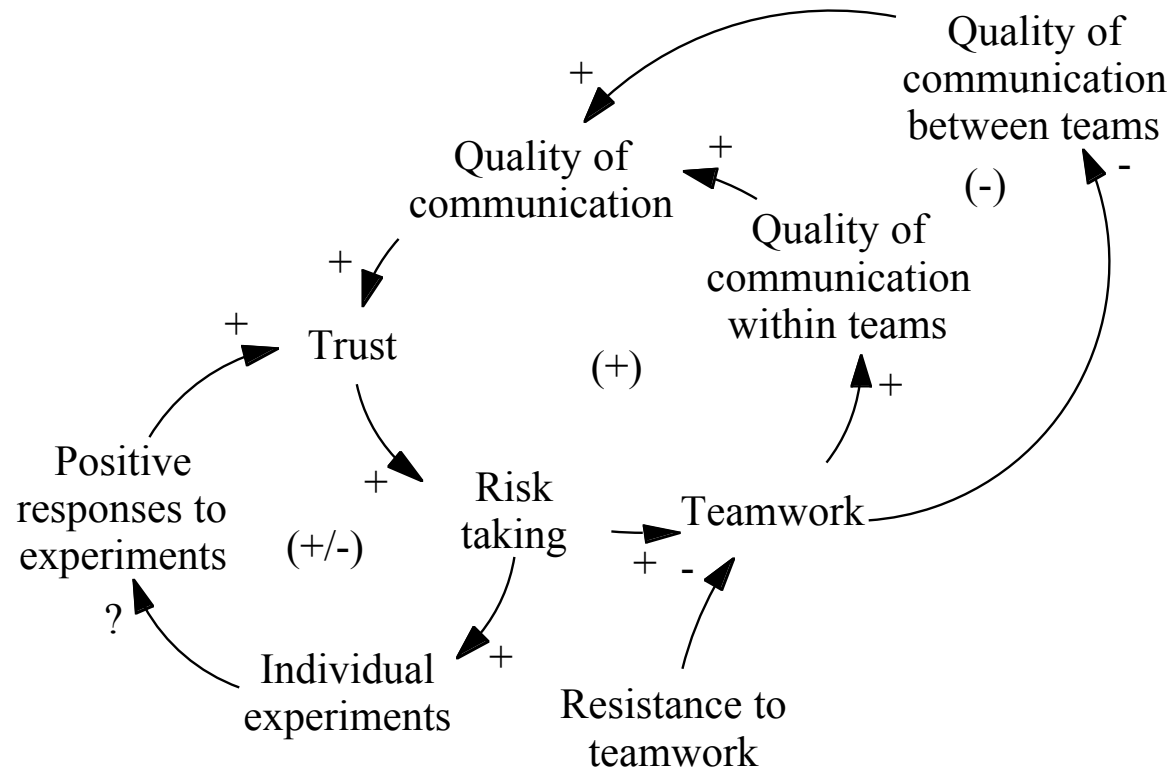
Some History: “Maps” and “Models”

- “Maps”: unquantified word-and-arrow diagrams — causal-loop diagrams, influence diagrams, maybe with representations of stocks
- “Models”: formal, quantified representations, captured in diagrams and equations, which can be simulated by computer

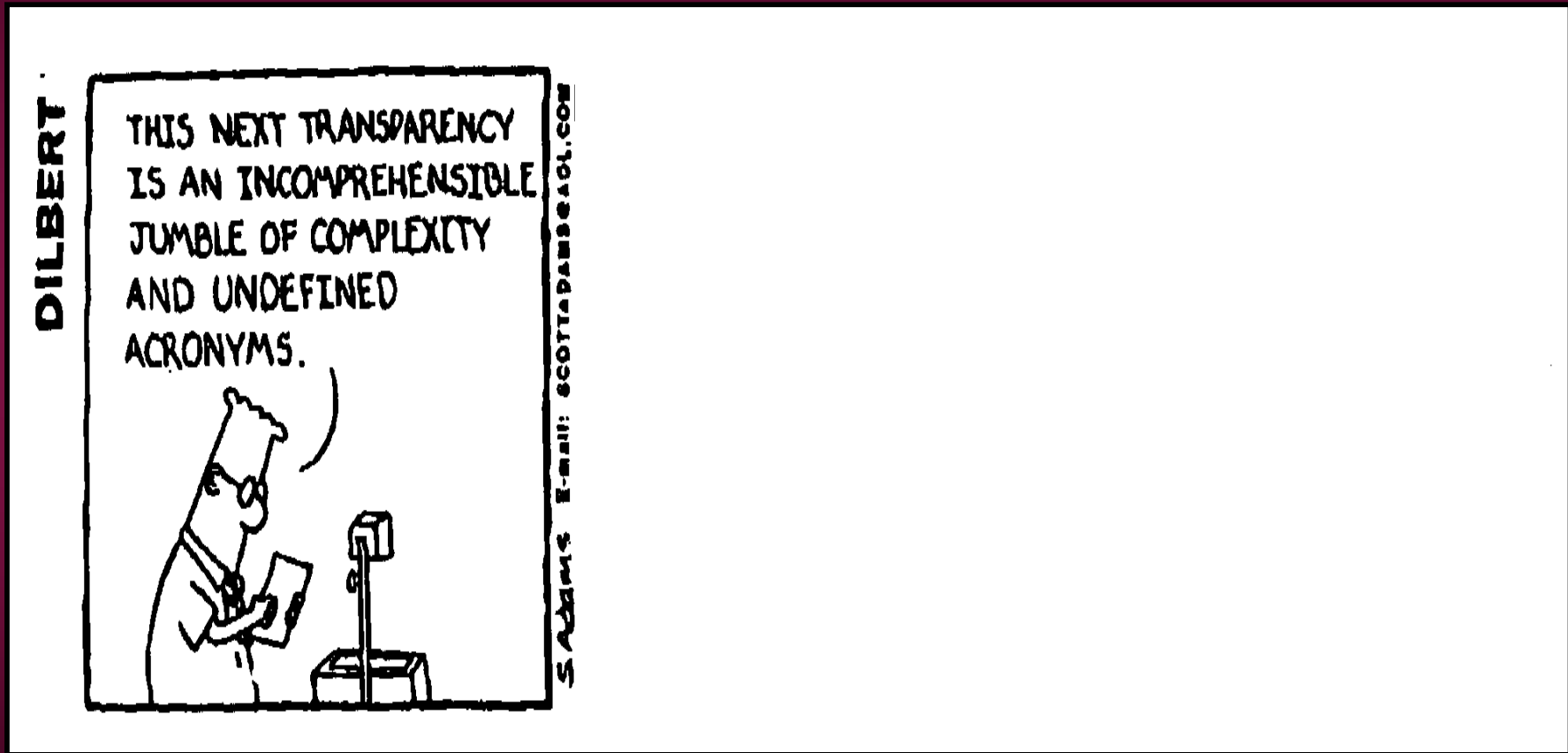
The Historical Questions

- Are maps by themselves adequate to support insights about complex dynamic systems?
 - Some say yes; some say no.
- Or, are formal mathematical models essential to ground insights in dynamic systems?
 - Some say yes; some say no.

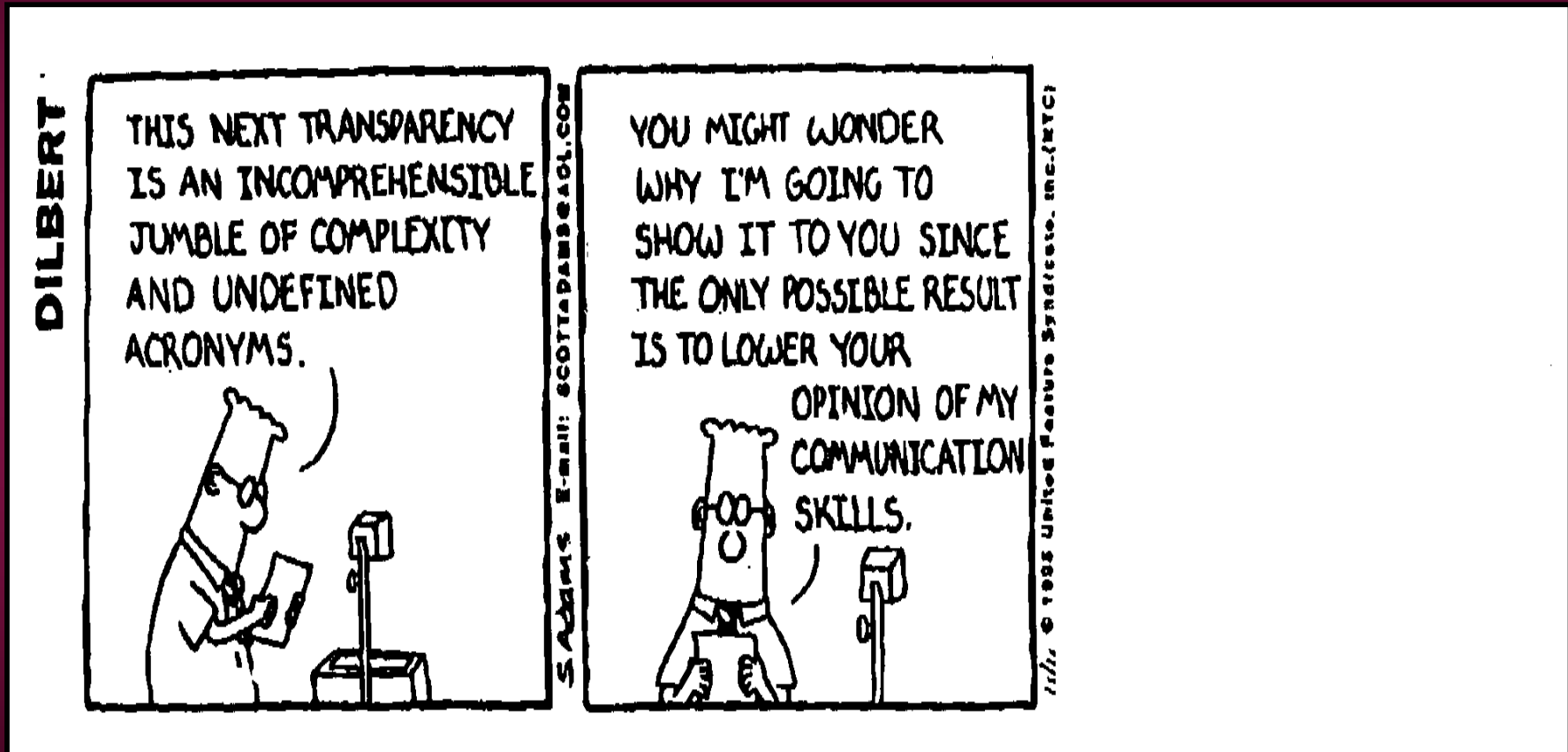
Isolation of teams, and punishing risk-taking inhibit the growth of trust



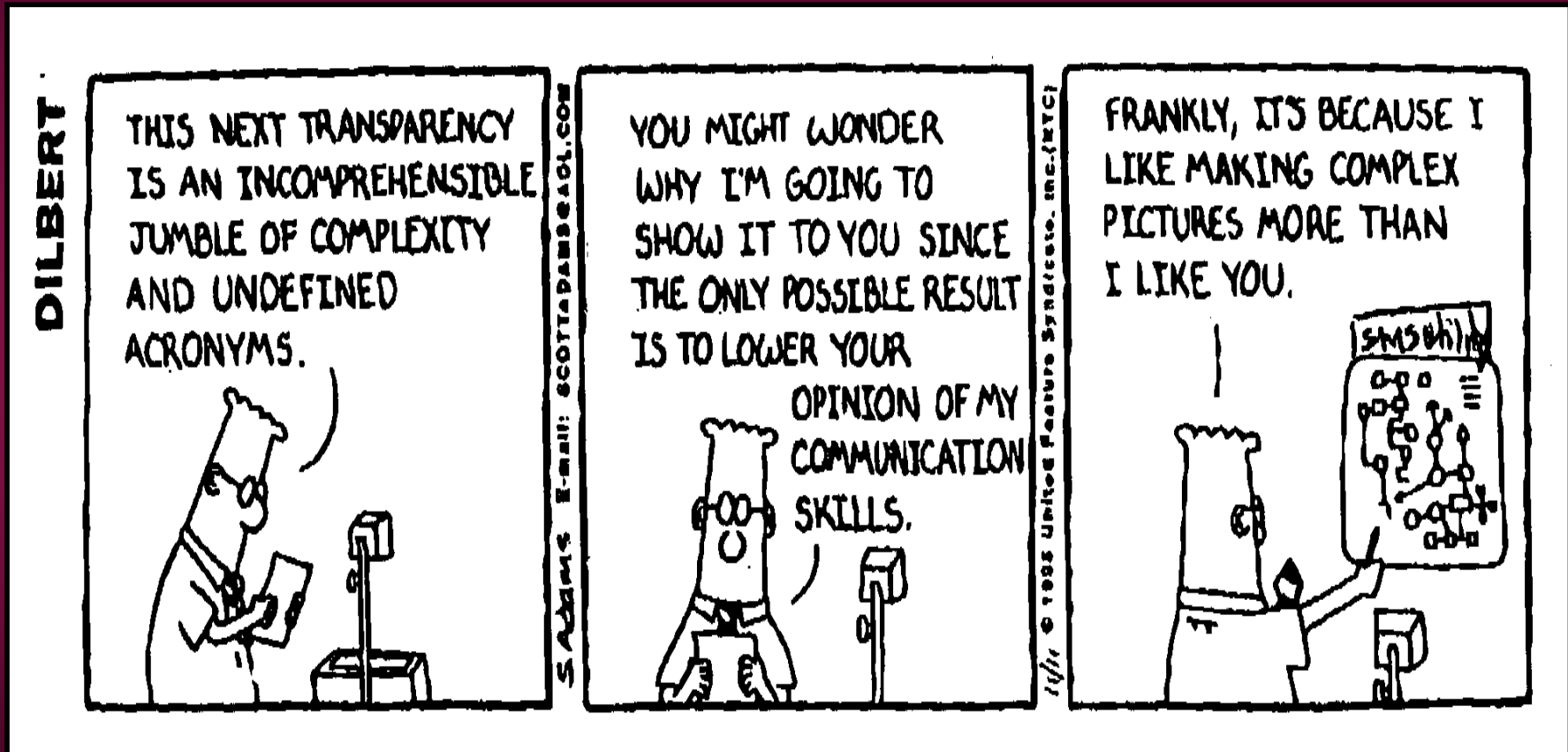
Increasing Complexity



Increasing Complexity

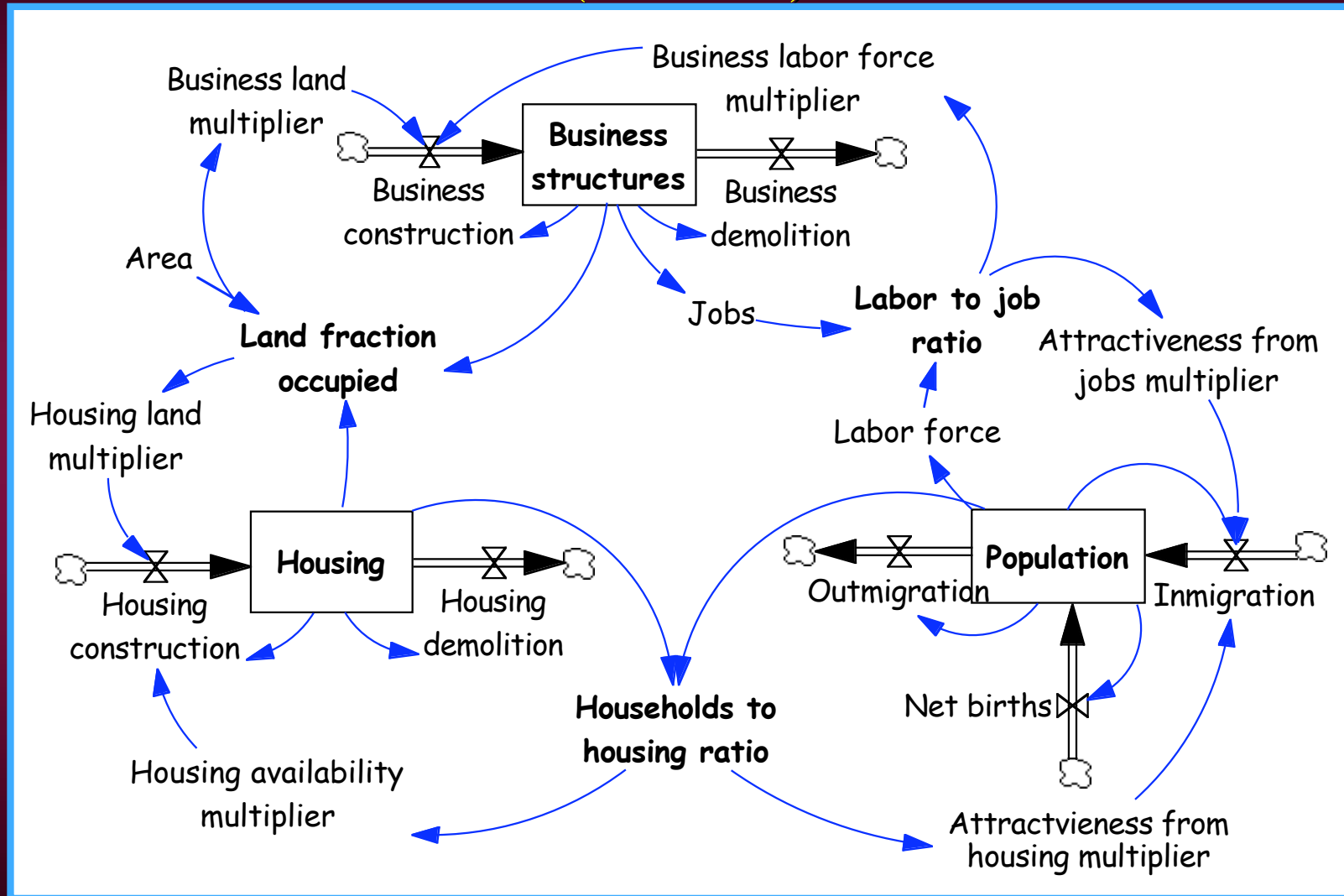


Increasing Complexity

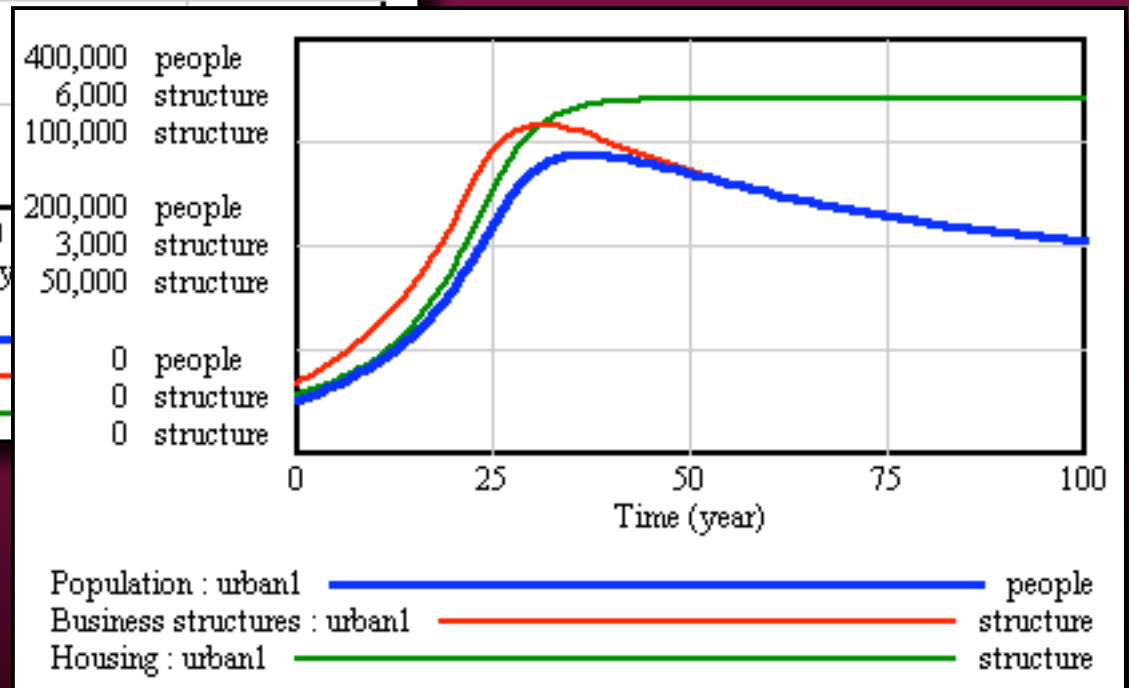
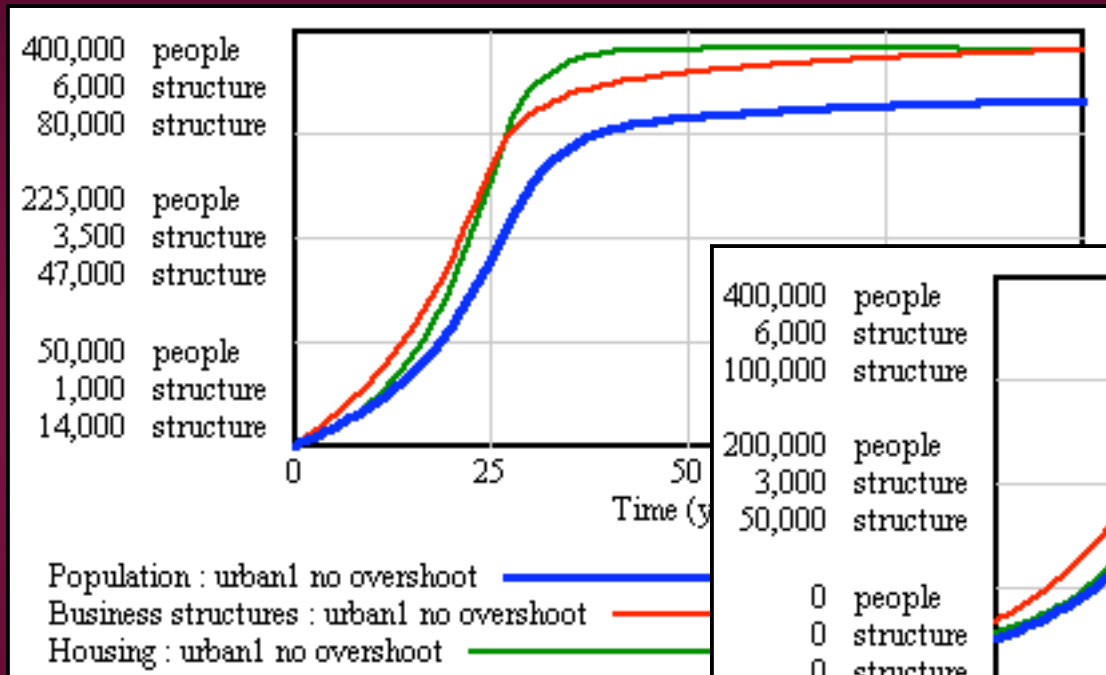


Urban Growth, Stagnation, & Decay

(or is it?!?)



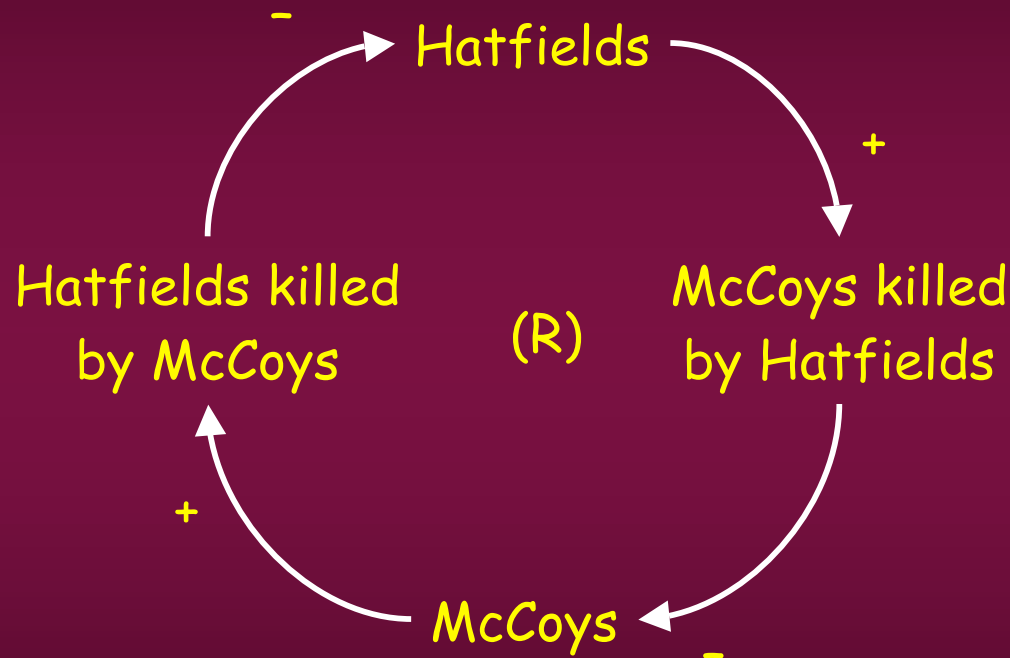
Maybe yes, maybe no...



Two Kinds of Insights

- Structural insights
 - “This structure (this loop, these few loops) has the potential to ...”
 - “We should be wary of”
 - “We should try to exploit”
 - “We should try to control”
- Behavioral or Dynamic insights
 - “This behavior is produced by this structure.”

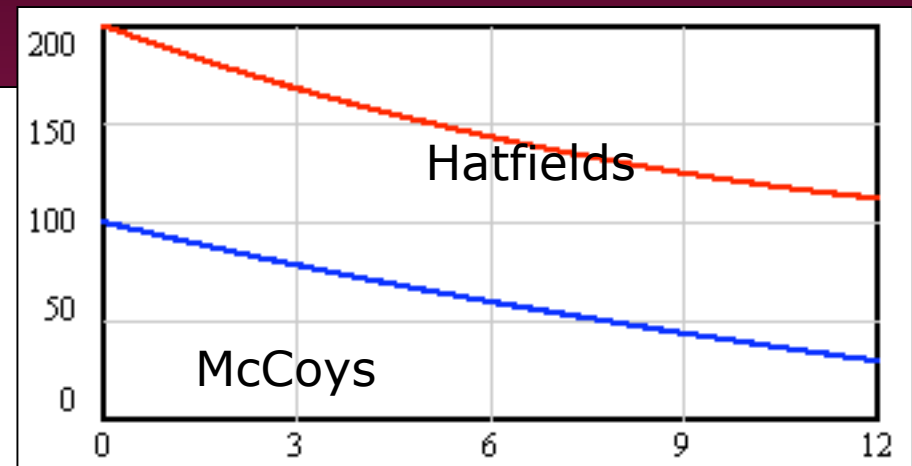
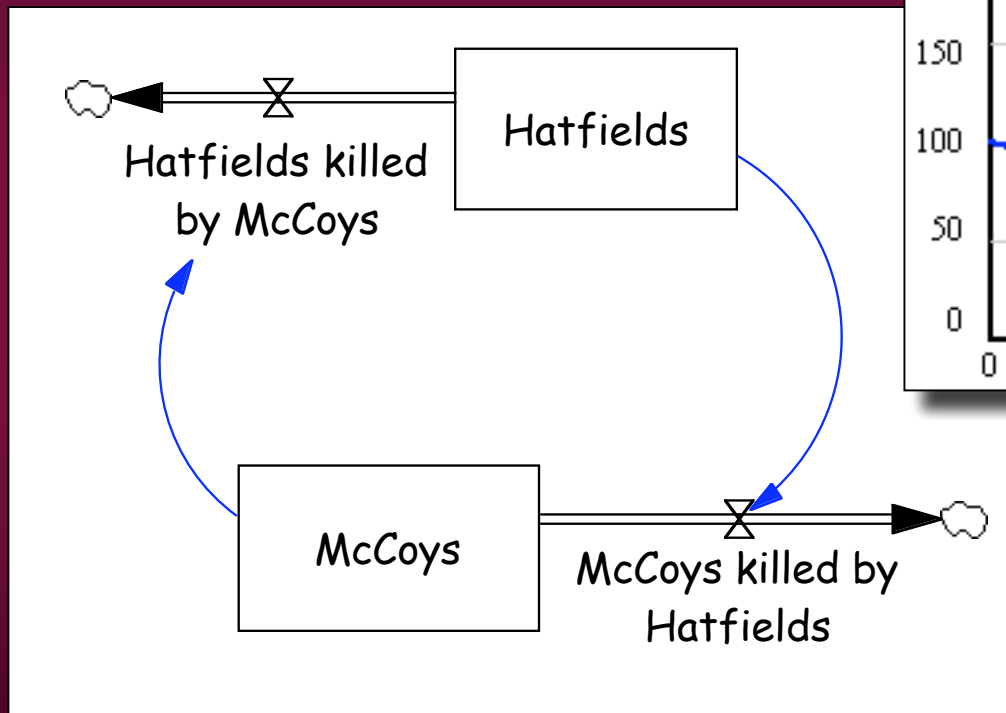
A Feud: A Cautionary Tale about Maps



The more Hatfields,
The fewer McCoys.
So the fewer Hatfields killed,
And thus the more Hatfields,
So still fewer McCoys,
And still more Hatfields.
And so on and on...

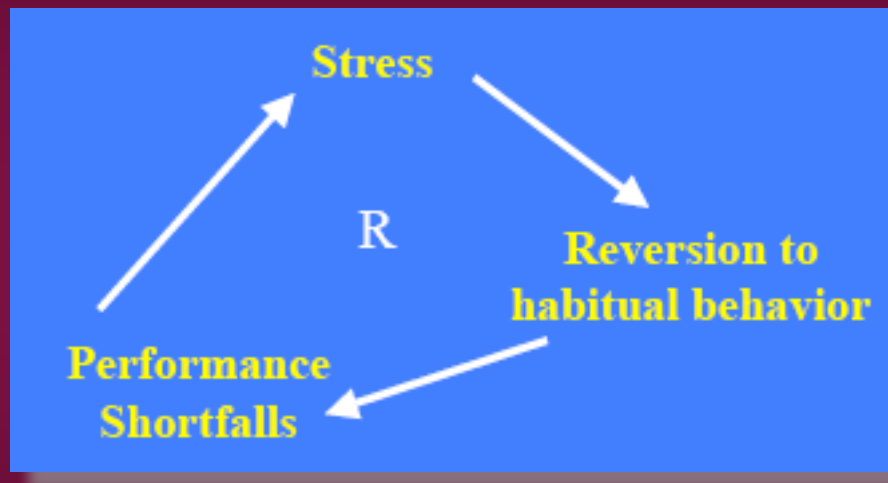
But you don't get more
Hatfields by shooting them!

The Real Structure & Behavior of a Feud



The negative links in the CLD are *outflows*, so the populations always decline!

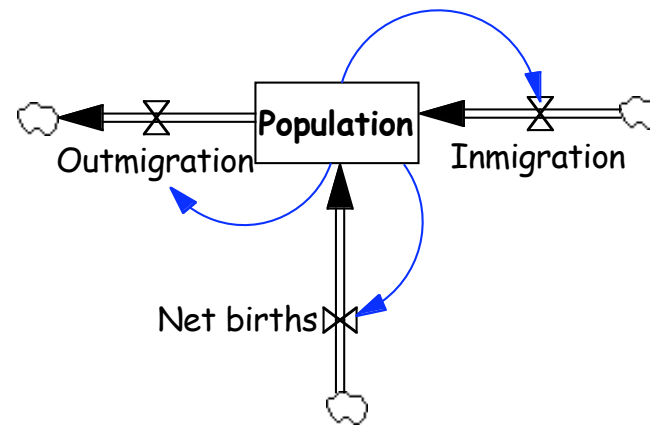
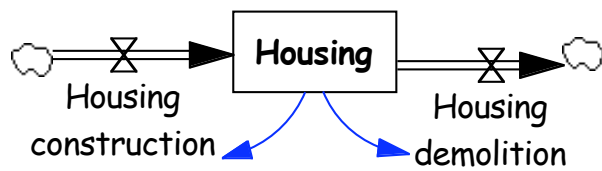
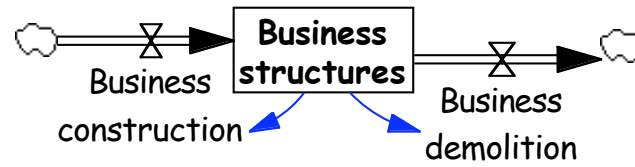
An example from Barry's talk at the 2002 *Systems Thinking in Education* conference

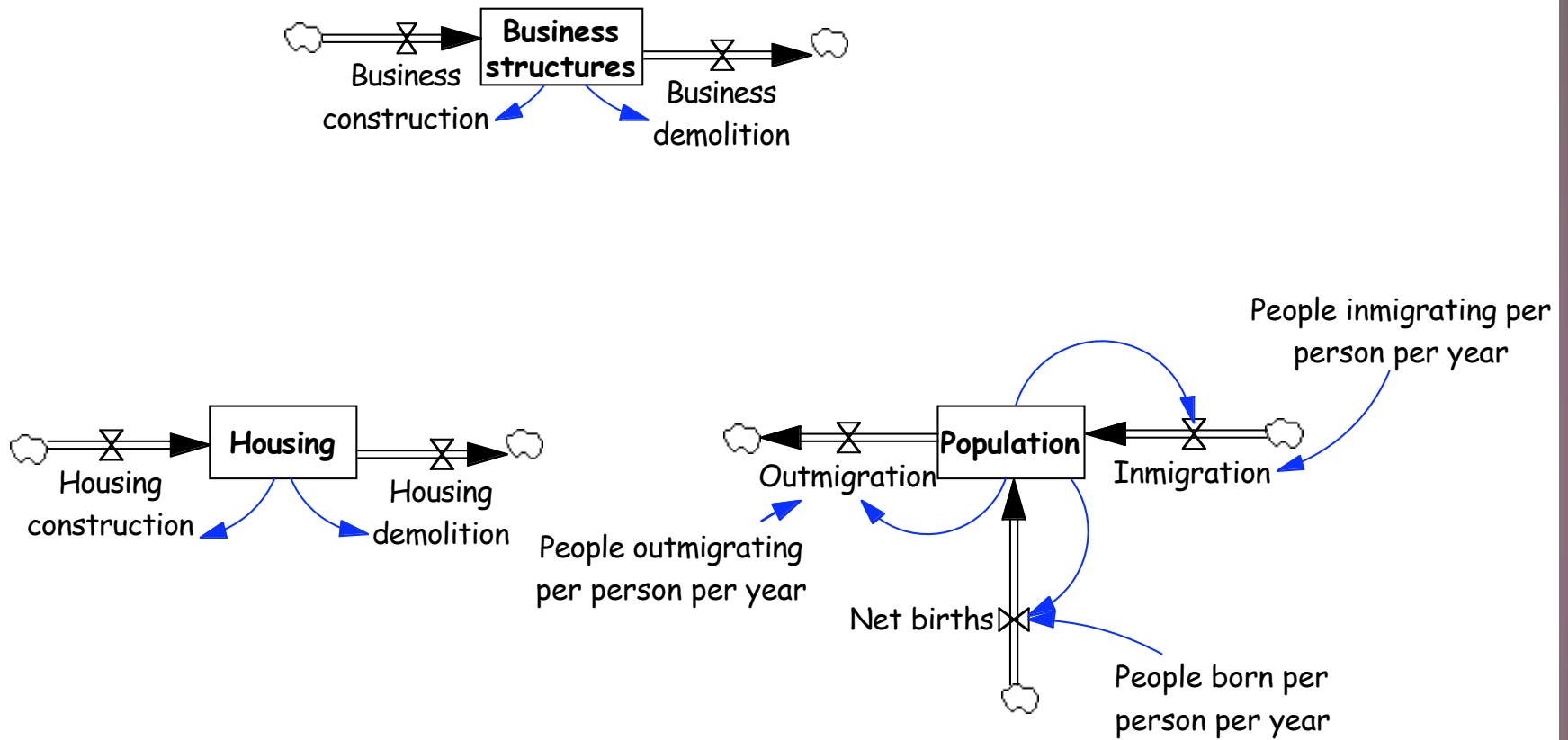


Barry praised Senge's use of this diagram to capture an insight

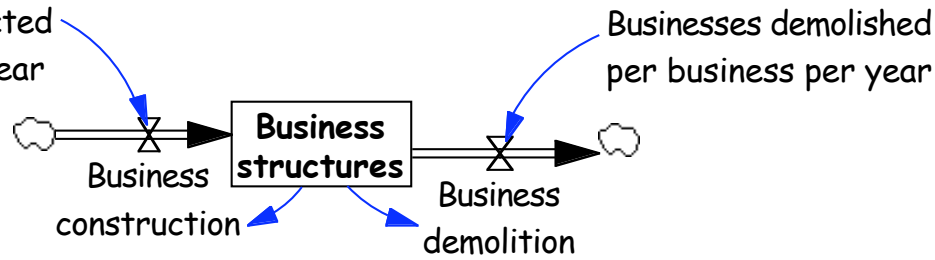
Barry's Thinking

- CLDs mislead, can mislead catastrophically
- So always start with stocks and flows
- In fact, in his latest thinking,
 - Start with nothing but stocks and flows
 - Add “productivity” converters to correct the units and the operational thinking for the flows
 - Then revise and add operational clarity

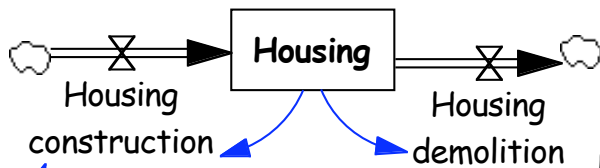




Businesses constructed
per business per year



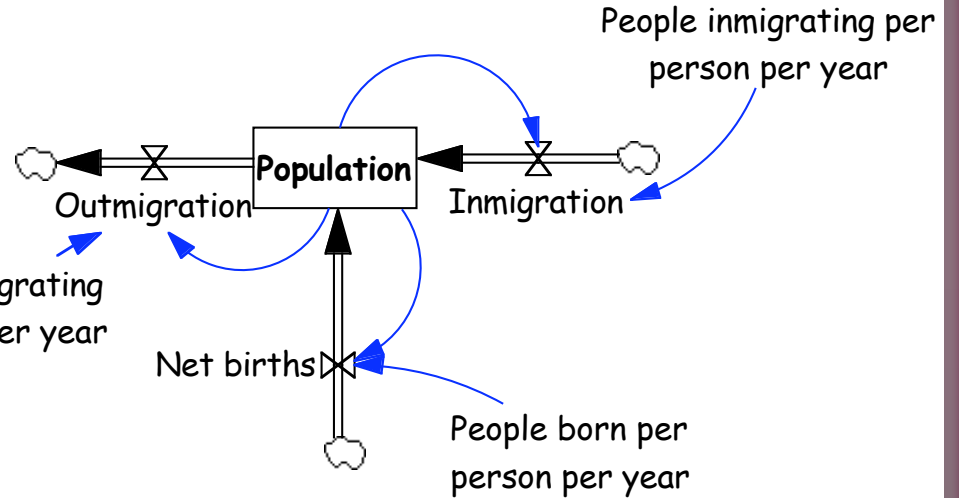
Businesses demolished
per business per year



Housing built per
house per year

Housing demolished
per house per year

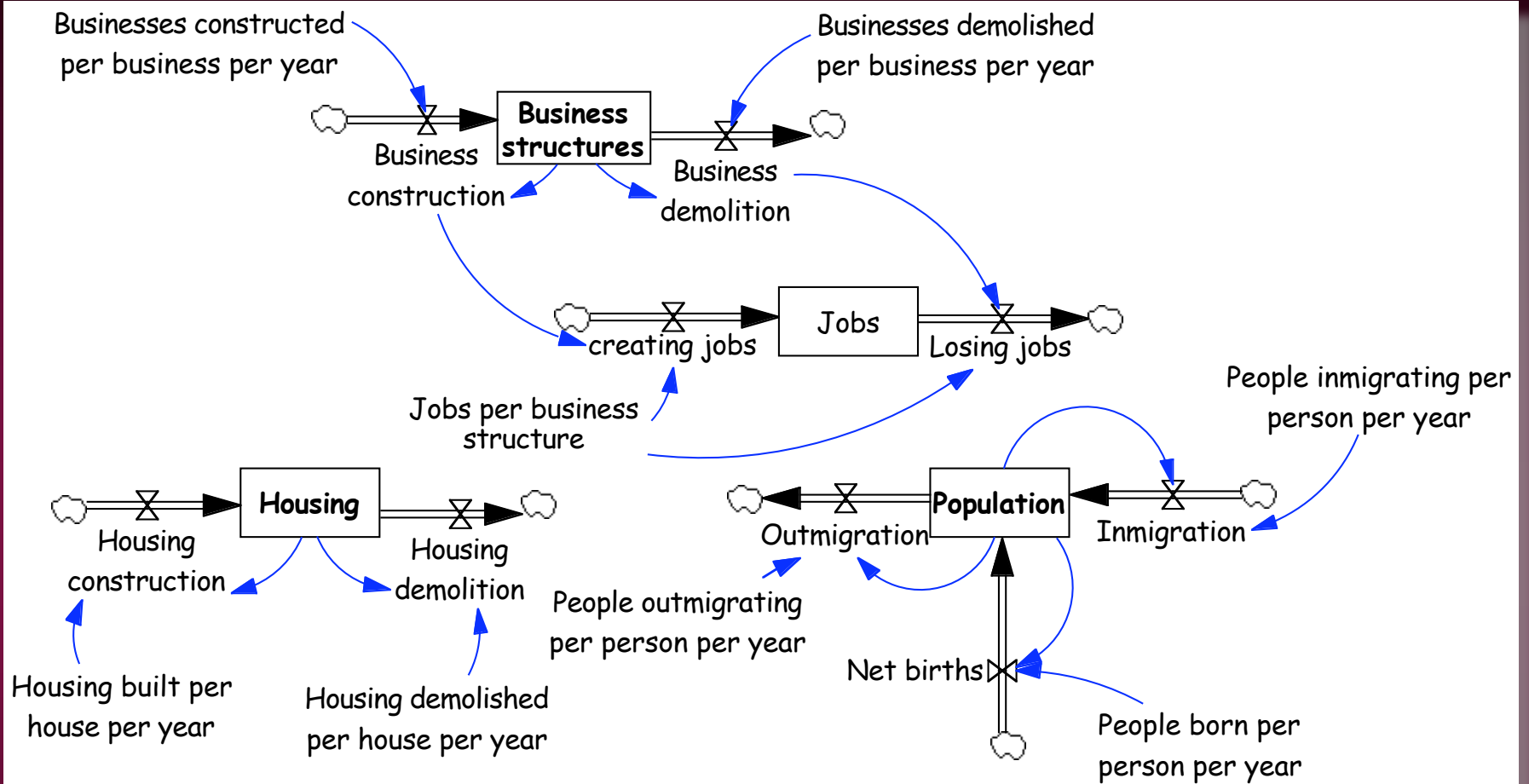
People outmigrating
per person per year

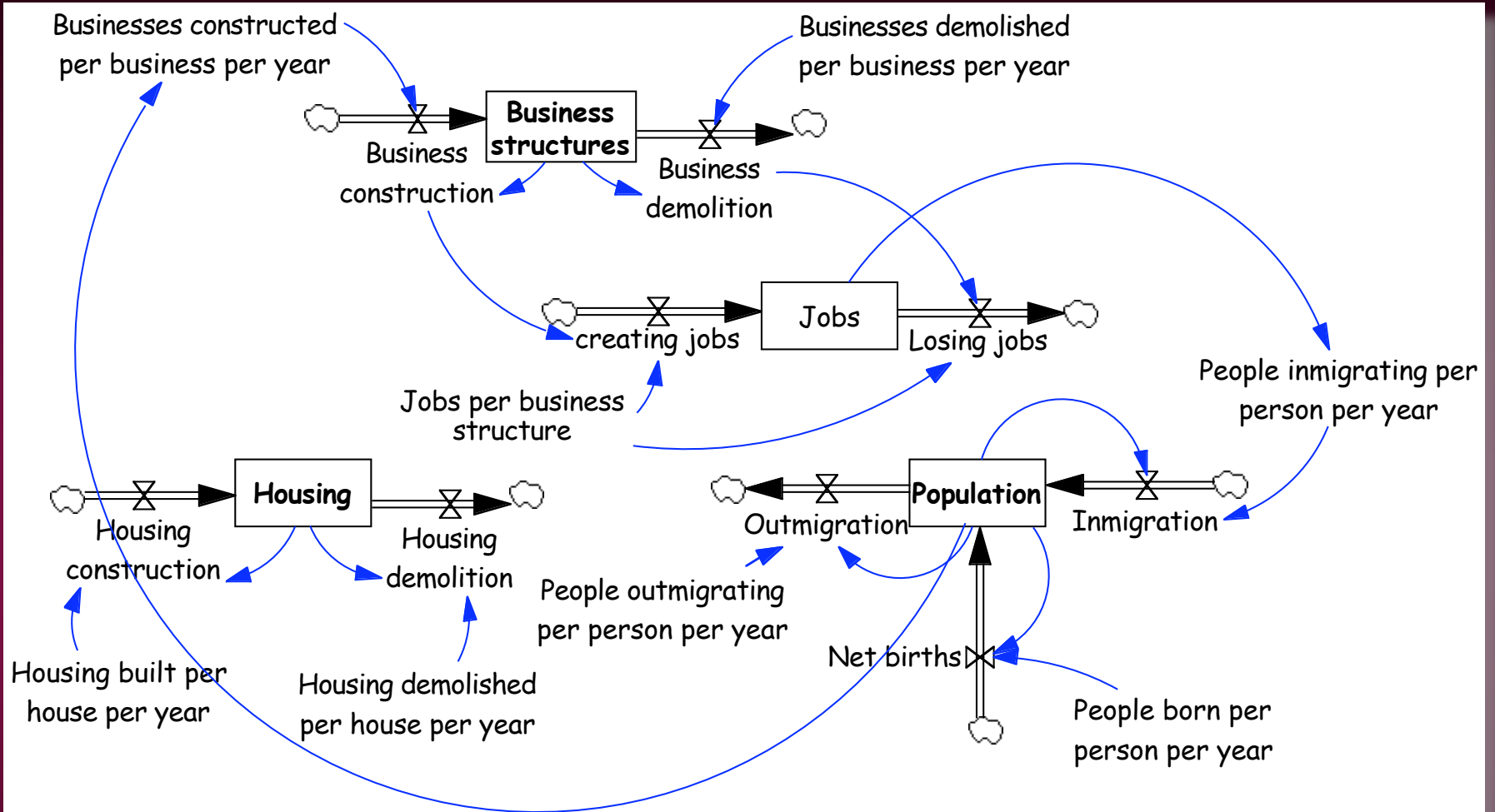


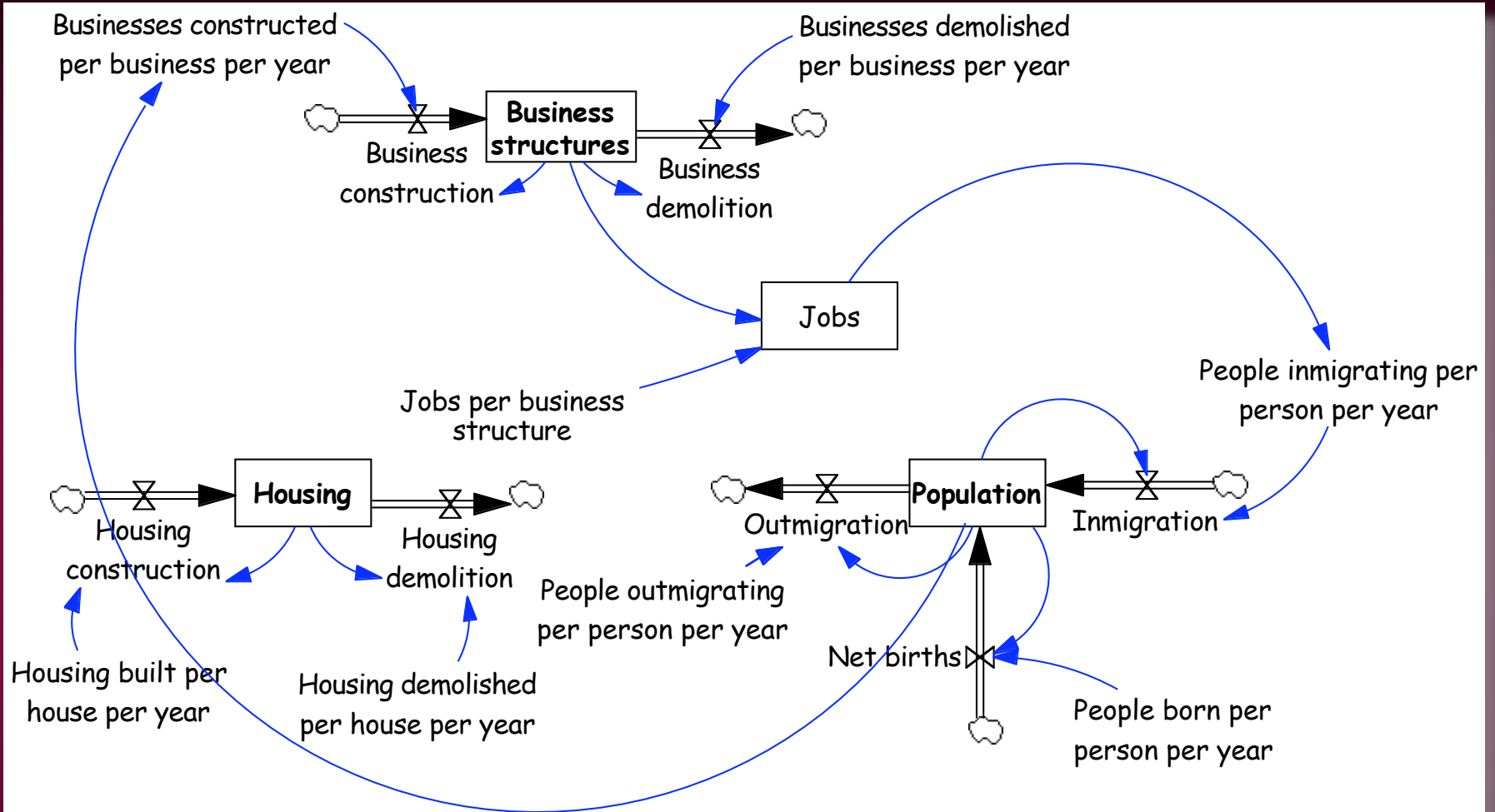
People immigrating per
person per year

Net births

People born per
person per year

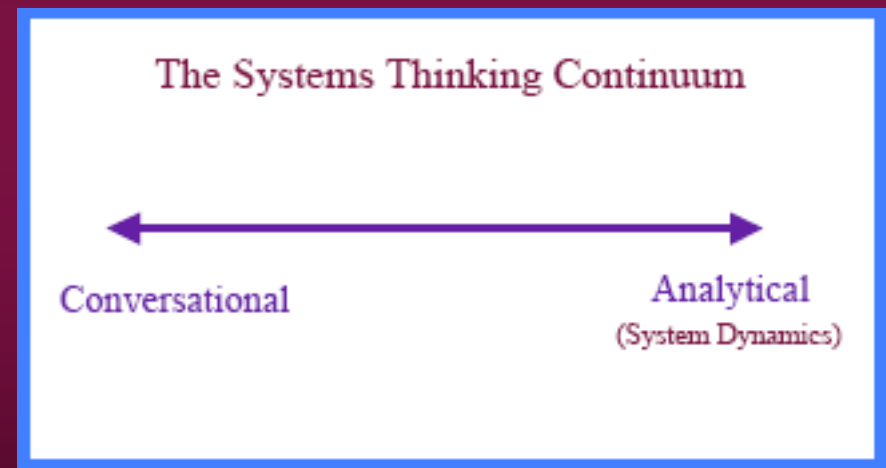






Barry: “What distinguishes/defines Systems Thinking is a unique collection of thinking skills...”

- **Filtering skills**
 - 10,000 Meters Thinking
 - System as Cause Thinking
 - Dynamic Thinking
- **Representing skills**
 - Operational Thinking
 - Closed-loop Thinking
 - Continuum Thinking
 - Nonlinear Thinking
- **Simulating skills**
 - Quantitative Thinking
 - Scientific Thinking



Barry's Model Improvement Phase

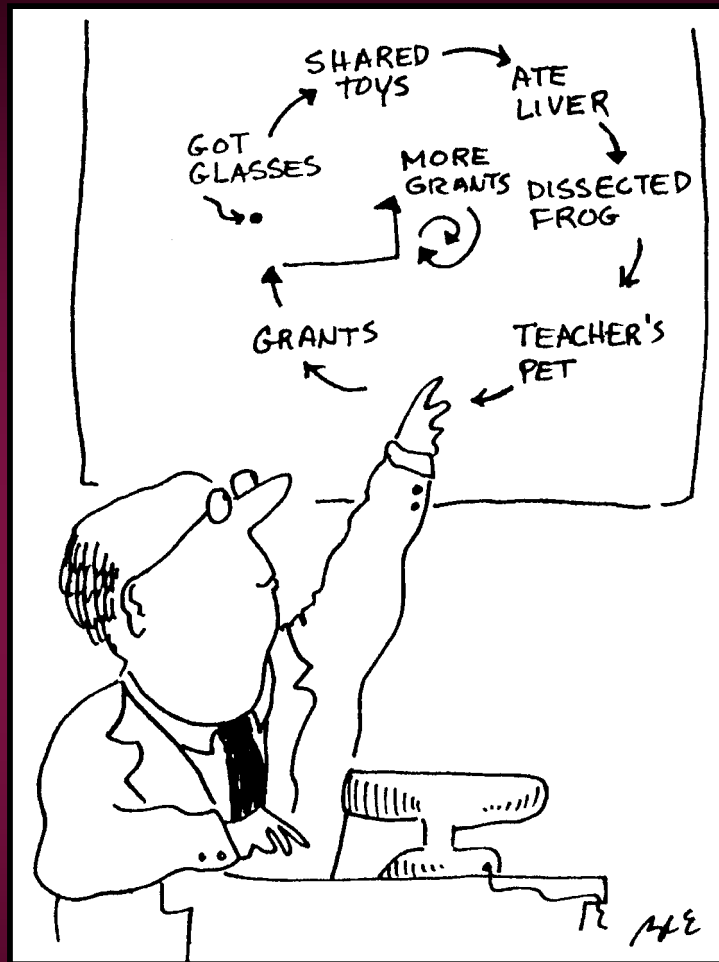
- Think about the duration (time constants) of the stocks and replace with algebra (converters) if duration too short for time frame of system
- Think *operationally* throughout
 - Respect the difference between stocks and flows
 - Respect unit consistency
 - Think in terms of how *things really work*
- ... (there's much more richness here: see *Introduction to Systems Thinking*)...

George's Thinking

- Start almost anywhere, but with stocks and flows in causal paths if you can.
 - But sometimes trying to find stocks and flows at the start can prevent getting started, so...
- Be flexible, eclectic, nondogmatic. ... Do what works in the situation.
- Use intuitive word-and-arrow maps to make headway, if necessary, and see the beginnings of feedback insights.
- *Purge forever the idea of separate kinds of diagrams, but rather employ a continuum of ever clearer, more operational, useful, and insightful diagrams.... (It's like writing.)*

George's "Map Improvement" Phase

- Rephrase "concepts" as "variables"
- Clarify foggy concepts or ambiguous causality by adding essential word phrases and links
- Identify units early on, even in CLDs
- Iteratively "re-map" so all variables, causal paths and loops get clearer and make more and more operational sense
- *General strategy: Work consistently toward a "formal map" – a map that can be turned directly into a formal quantified model*



We could even start with this level of conceptual confusion and move (gradually) toward a well defined problem and a “formal map.”

“What do you really want?”

- Barry: Everyone an “operational” thinker
- George: Everyone a “feedback thinker”
- Well, no wonder we disagreed! We have different pedagogical goals.
- But it’s not that simple.

Goals

- Barry wants operational thinking.
 - But Barry also wants an endogenous point of view (and more -- “systems citizens”!), so he also wants rich feedback thinking.
- George wants feedback thinking.
 - But George wants extreme conceptual and causal clarity, so he also wants vivid operational thinking.
- We both can get both.

Map/Model Improvement

Various
starting
places

Processes for improving maps:



***Informal
maps***

- Stock-and-flow thinking
- Dimensional consistency
- Extreme causal clarity
- Operational thinking
- Nonlinear thinking

***Formal
maps***

***Formal
models***

Various
kinds

An Example from my Childhood

The more I study, the more I learn.

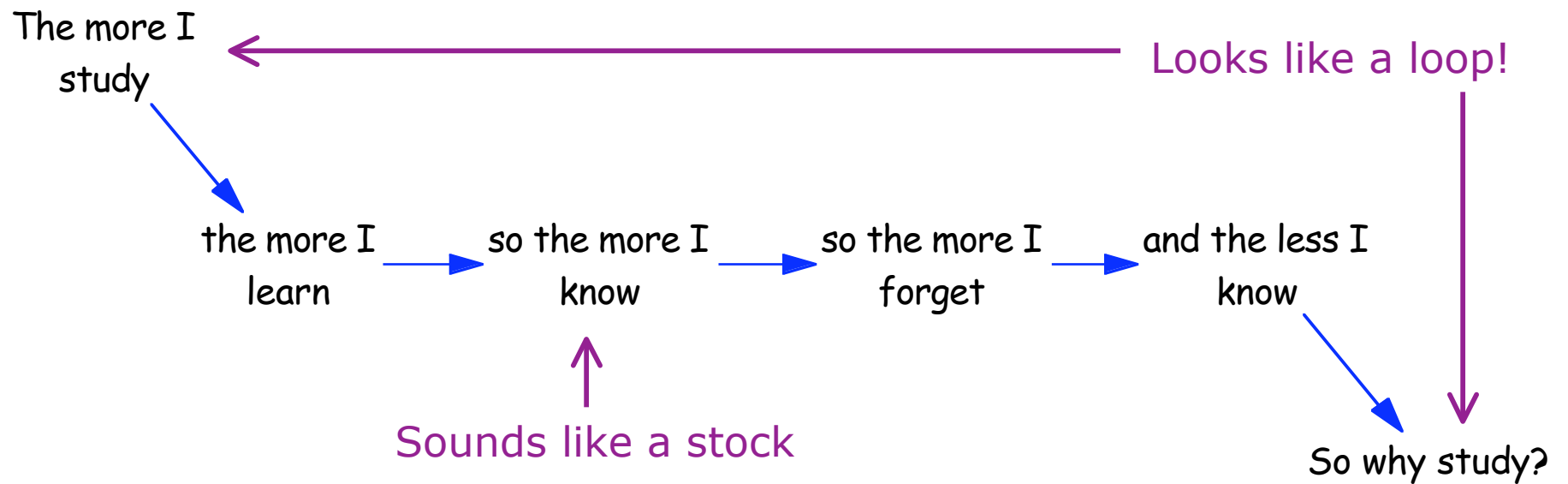
The more I learn, the more I know.

The more I know, the more I forget.

The more I forget, the less I know.

So why study?

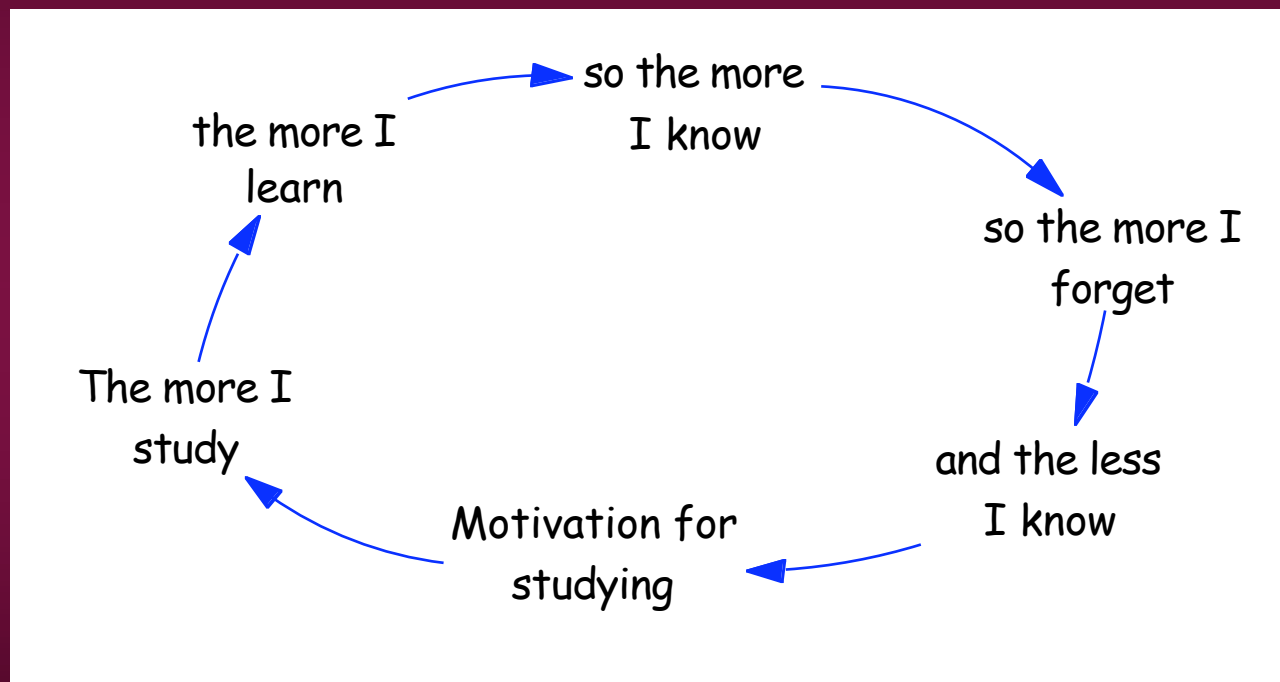
A first attempt at a causal diagram



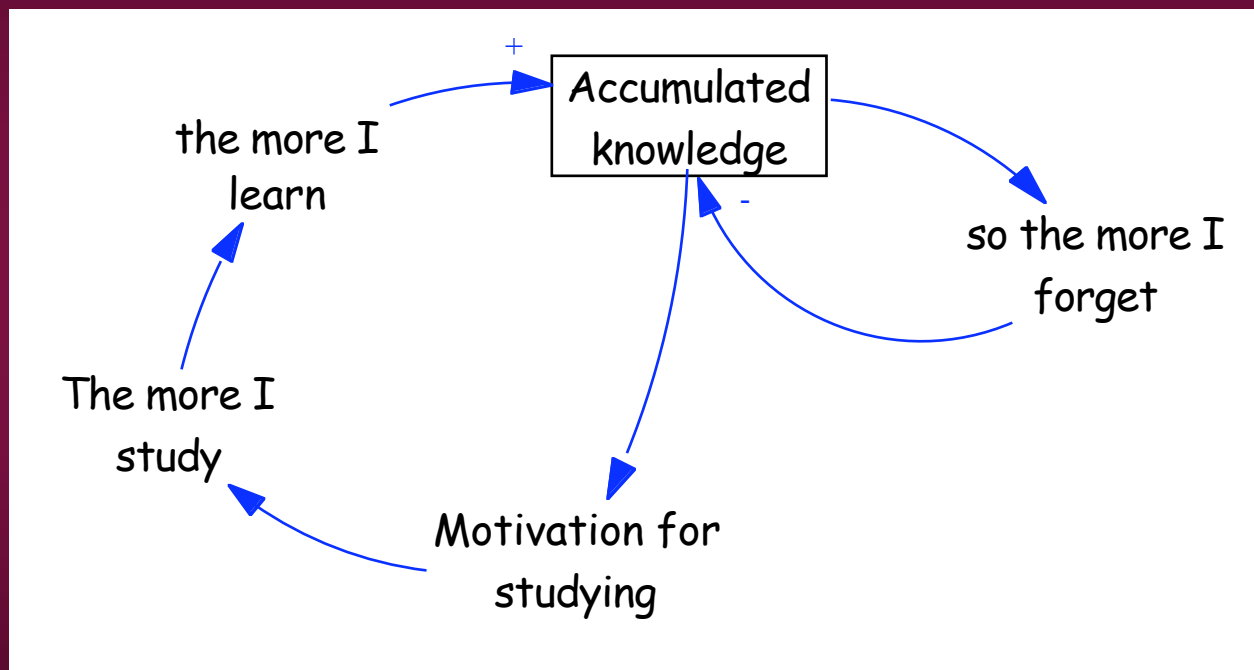
What to do first?

- Picture the stock(s) and flows?
- Close the loop?
- Rephrase everything as quantities?
- \implies Probably that last one first, but it doesn't really matter!

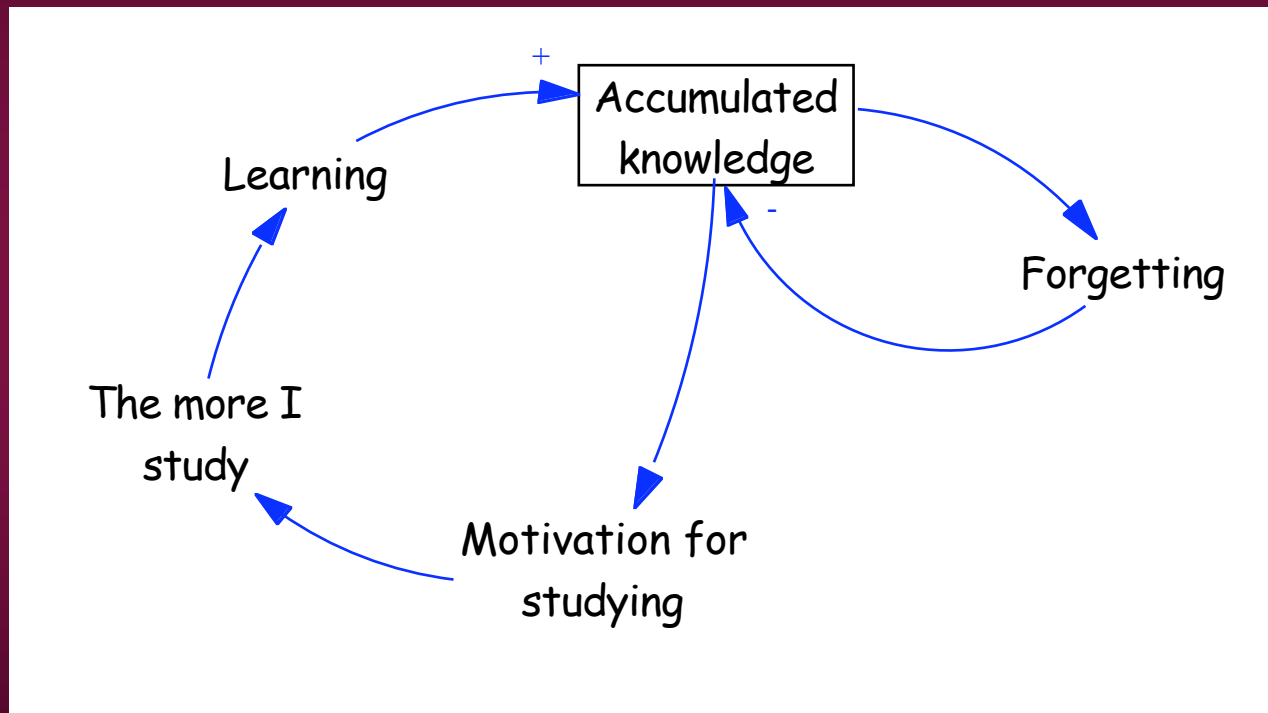
Closing the loop, replacing the question with a concept: *motivation*



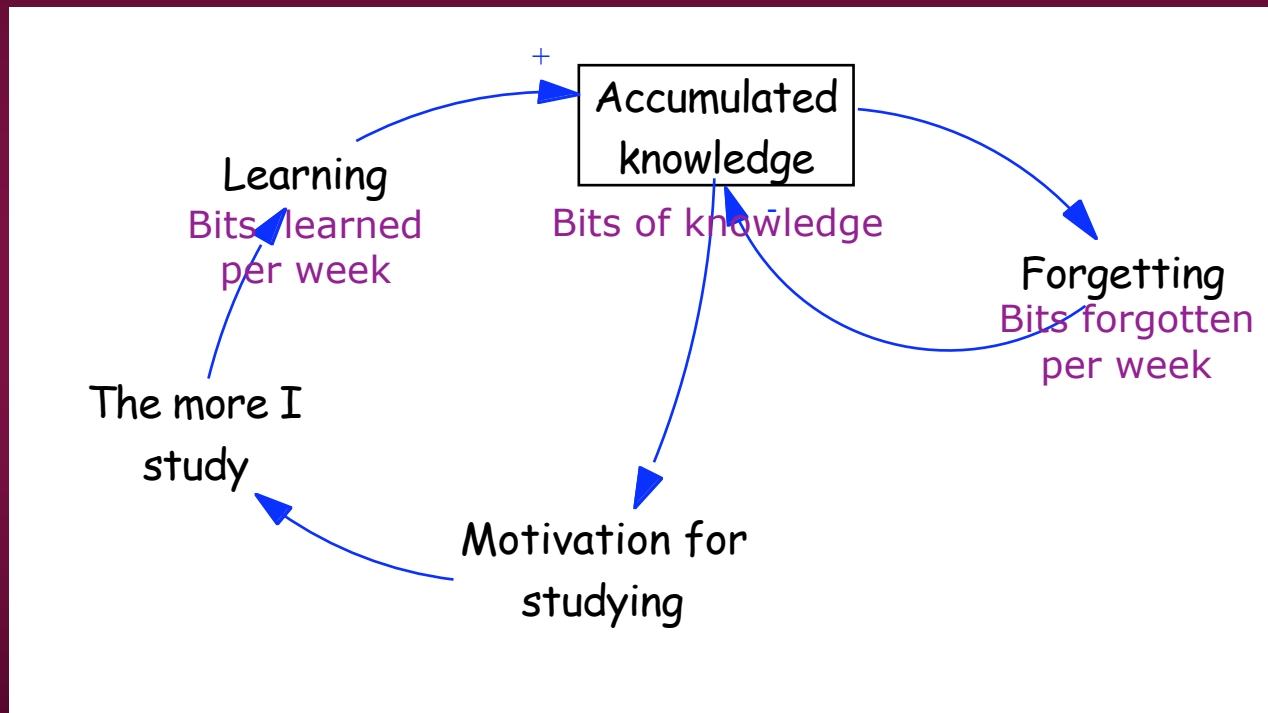
“The more I know” and “the less I know” are really the *stock* of Knowledge



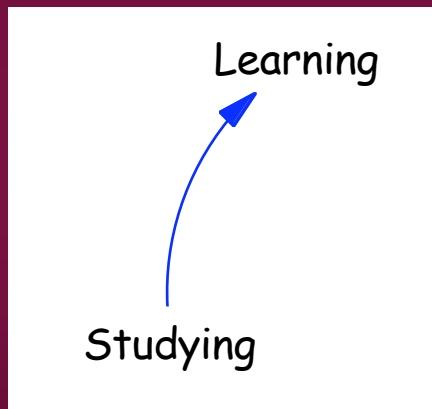
Learning and Forgetting are its inflows and outflows



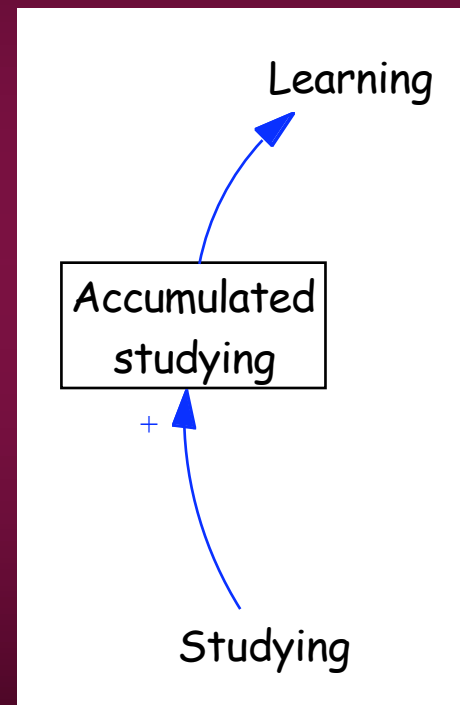
Units help tell what we really mean



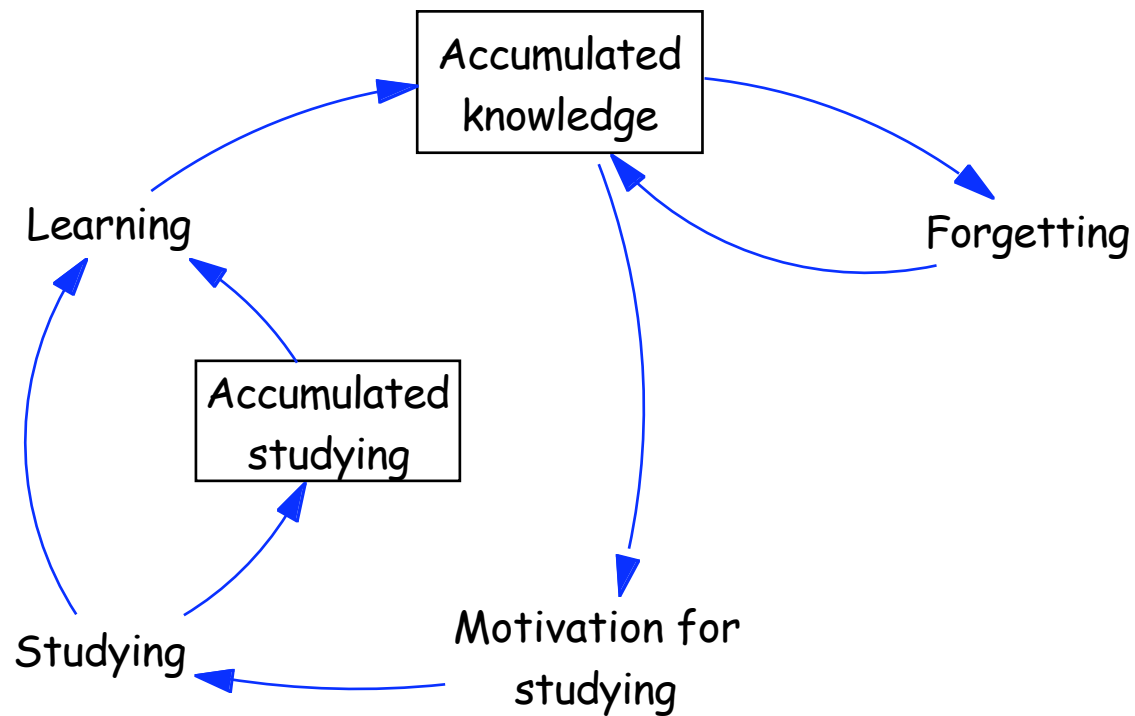
“The more I study, the more I learn...”



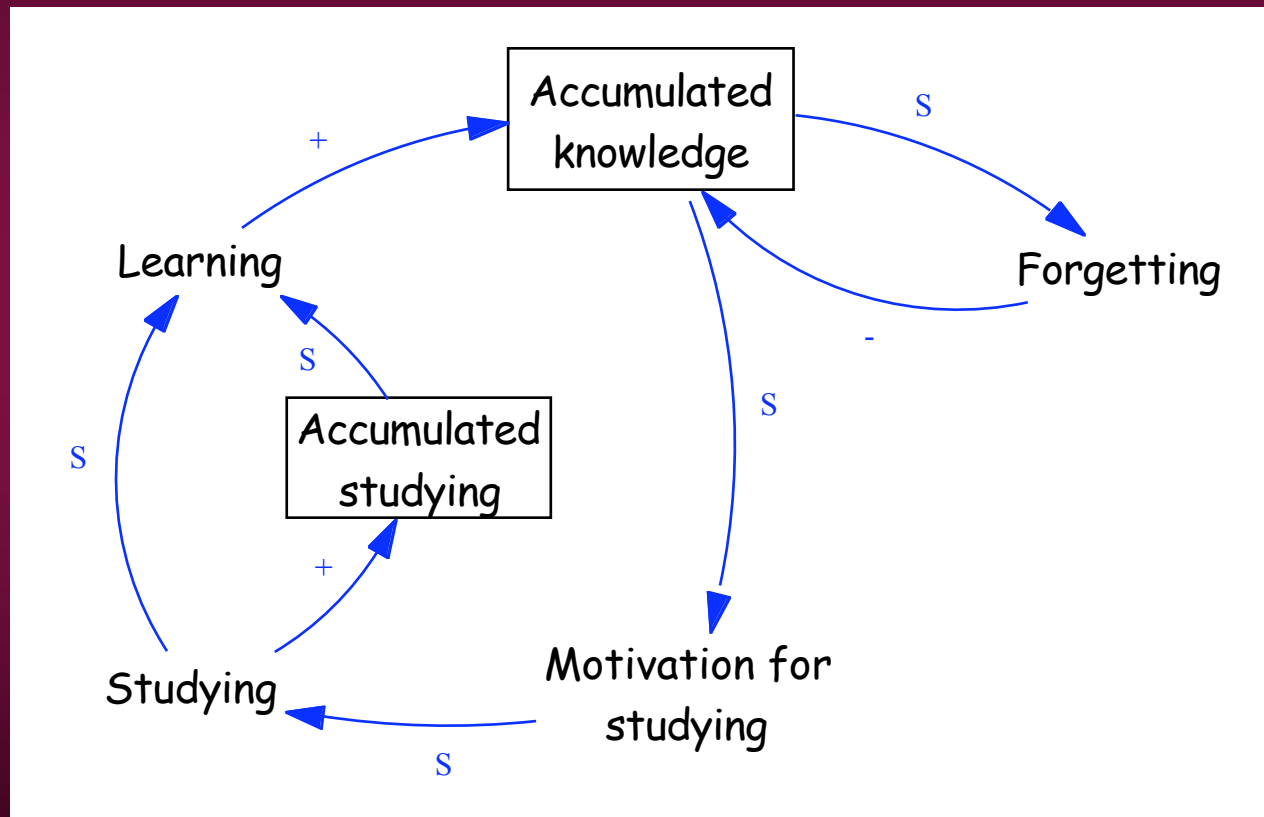
or



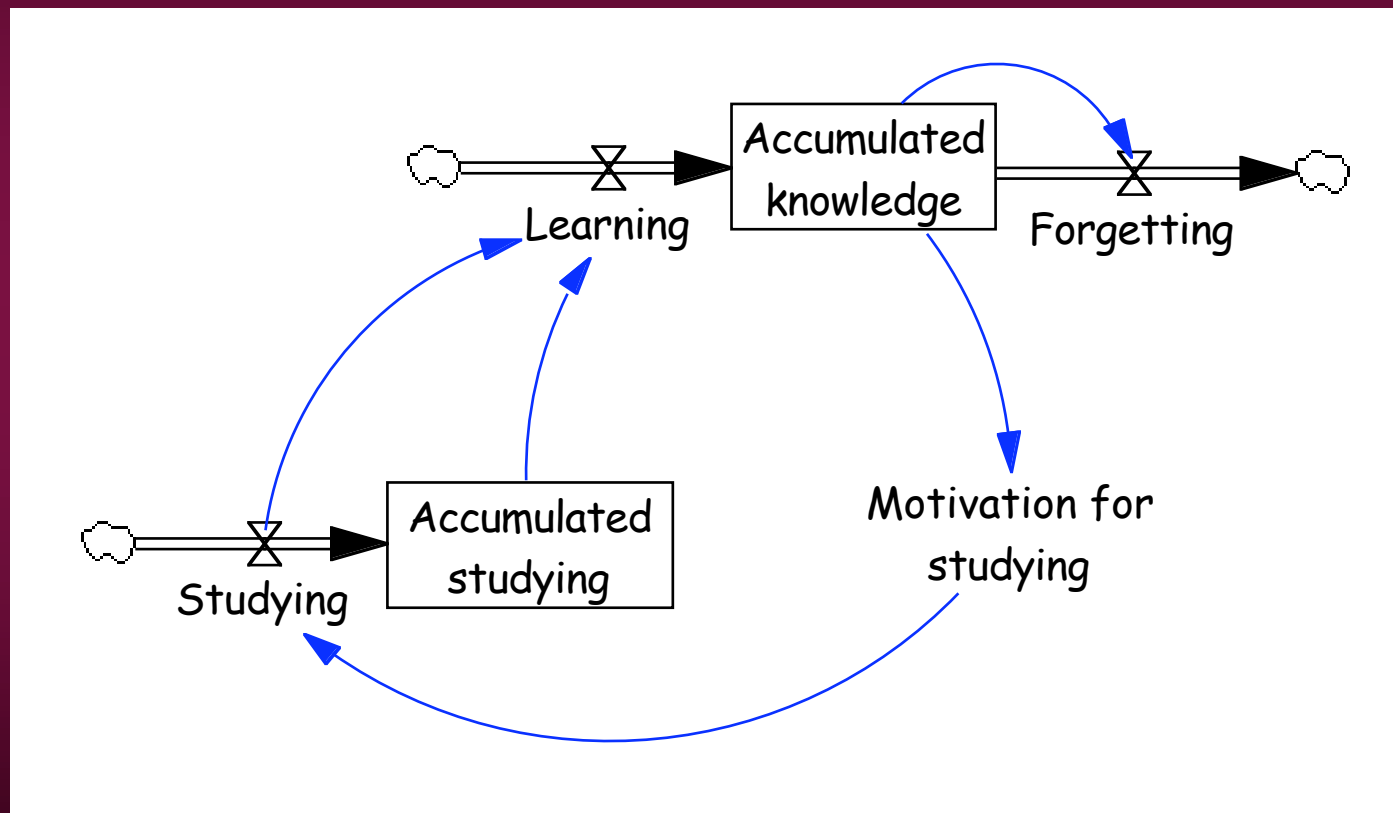
The whole story



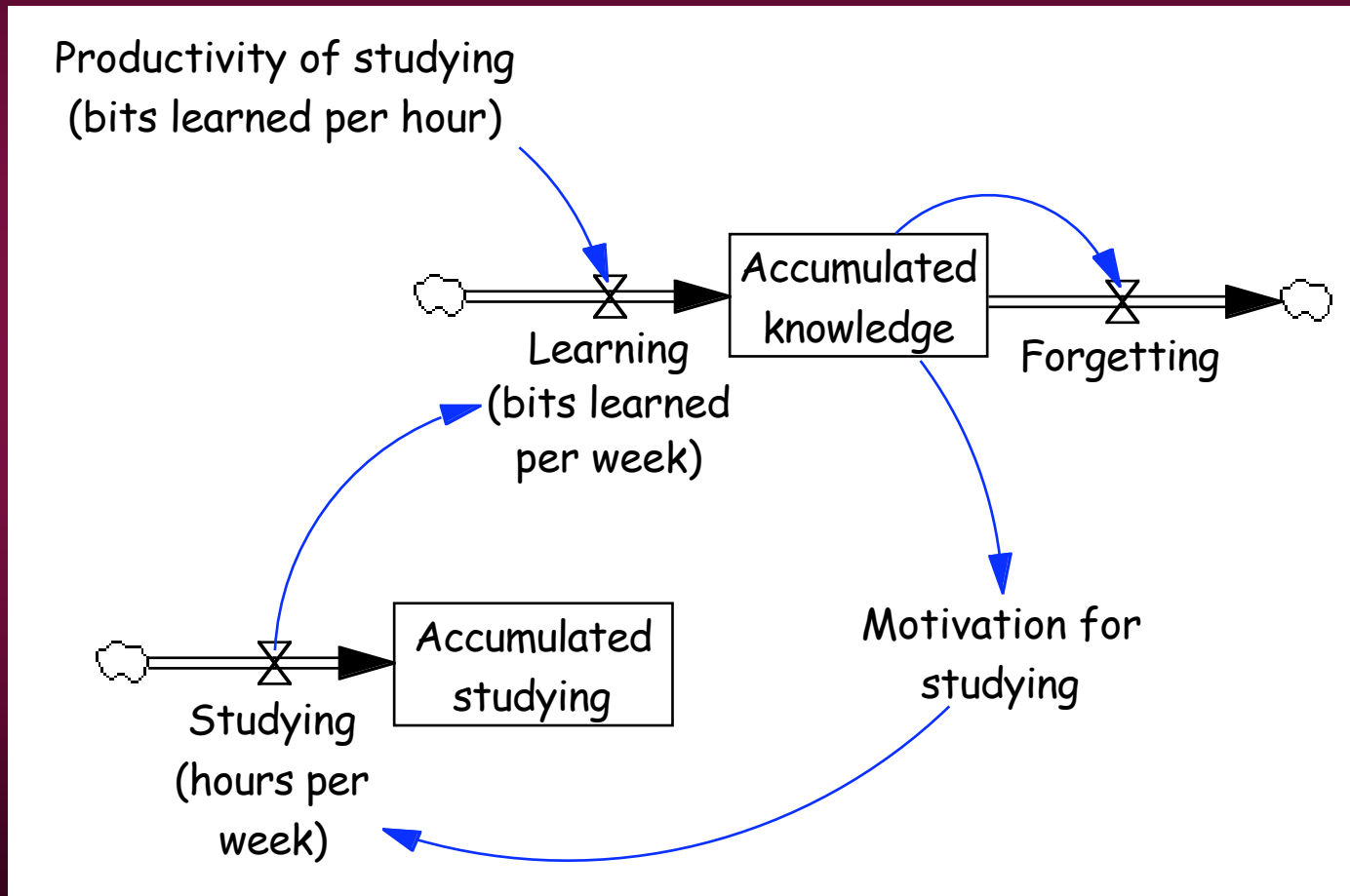
With link polarities



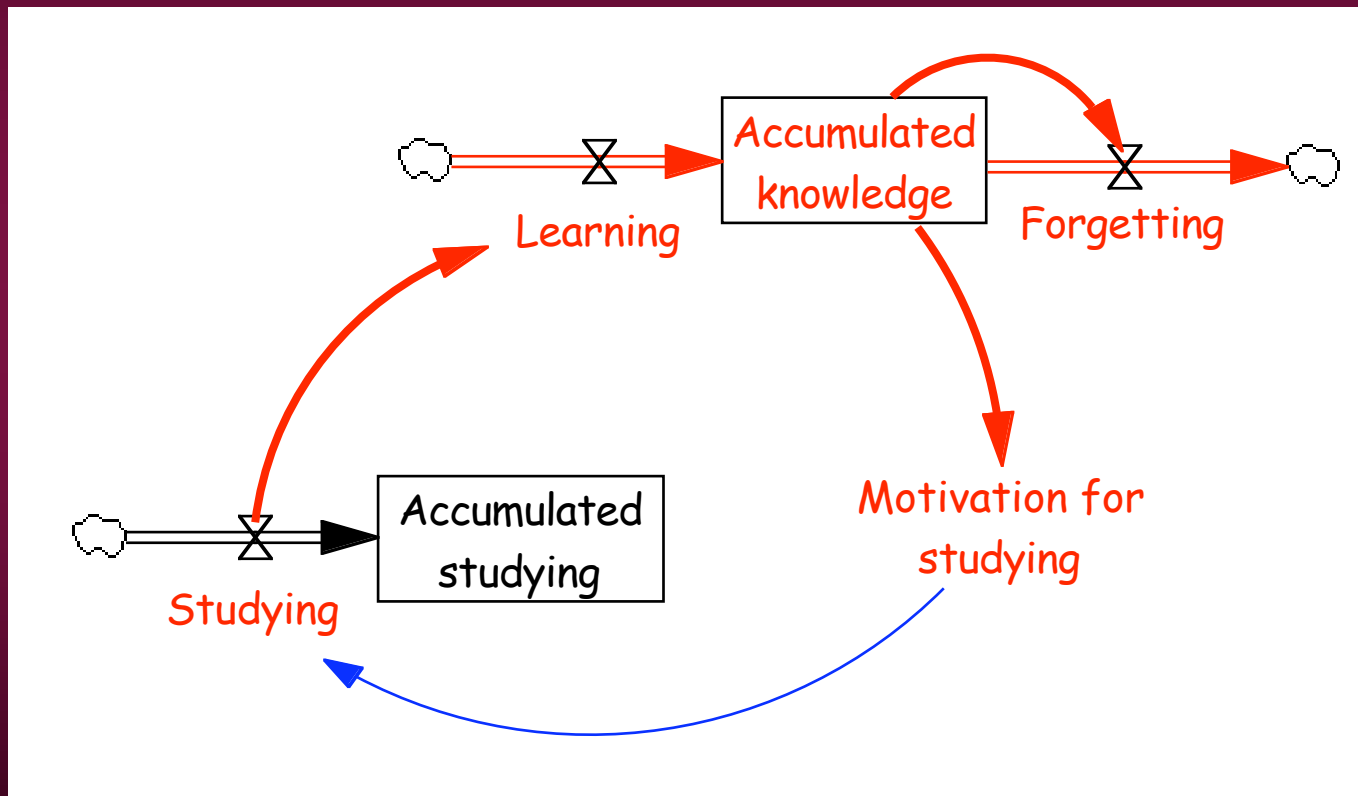
The map with pipes for flows



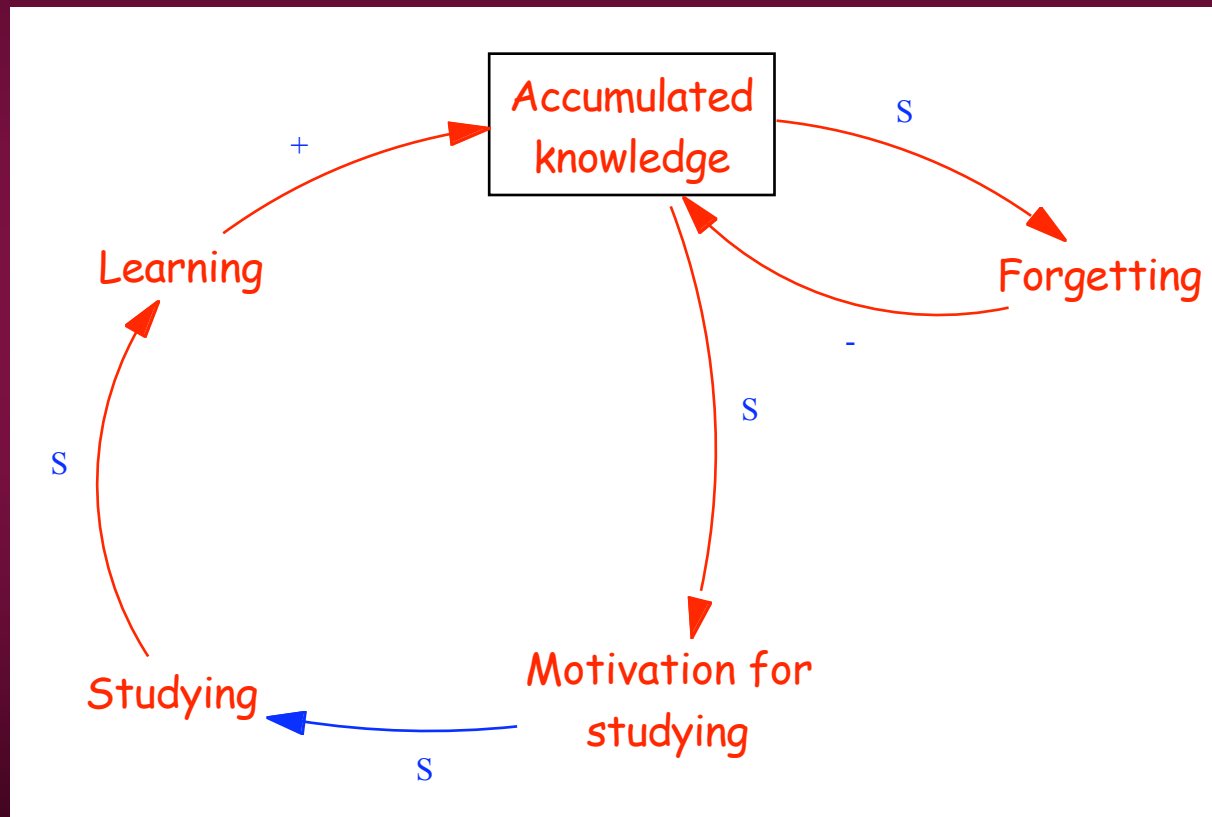
Heading toward quantification -- becoming clearer and more operational



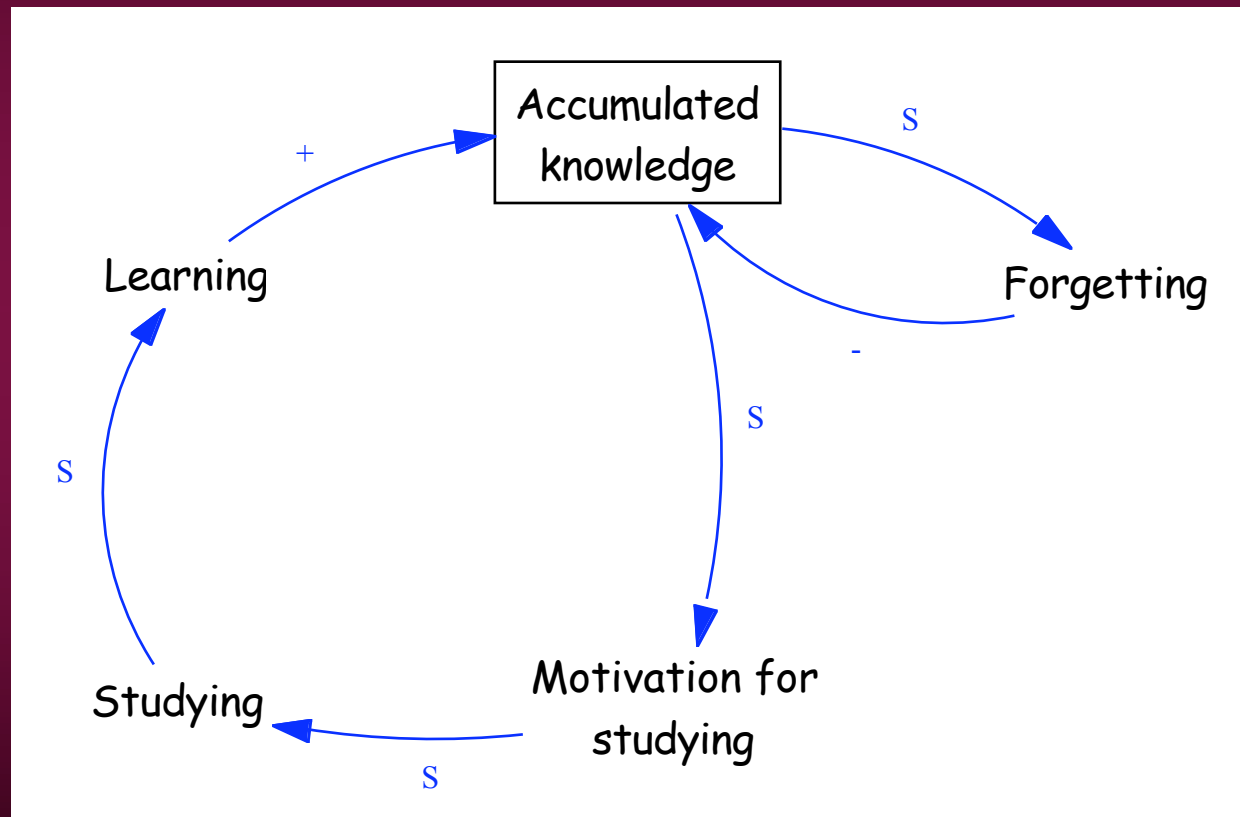
And where's our original story?



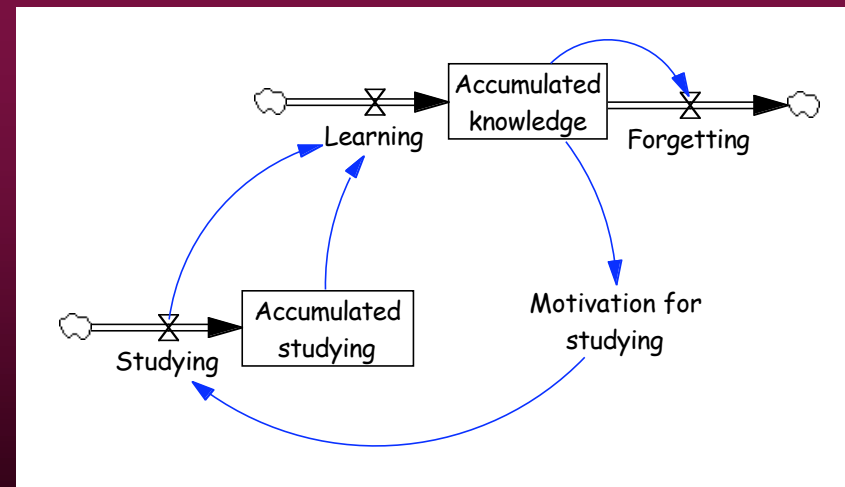
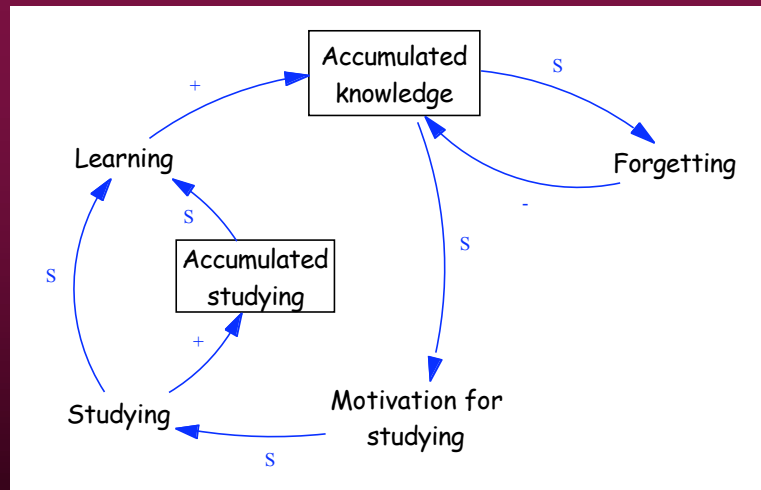
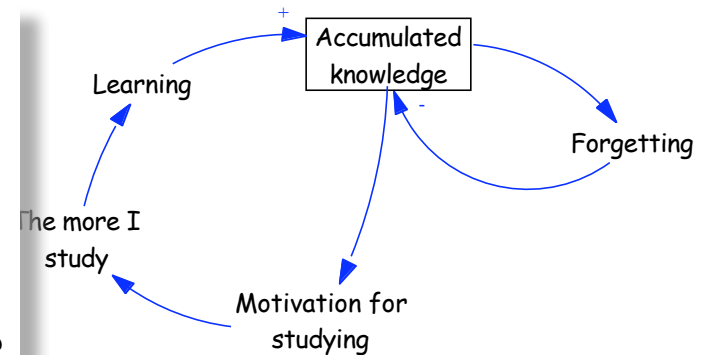
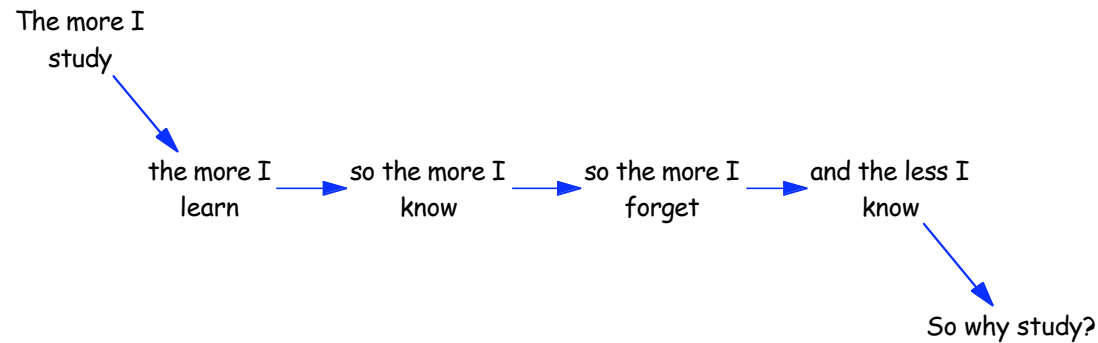
Or if you prefer...



An aside: Barry's serious observation on motivation



The Result: A sequence of improving maps



Thoughts about Process

- Turn words into quantities
- Identify accumulations (stocks: draw boxes)
- Strive for causal clarity; add word phrases (new variables) in causal chains if necessary
- Identify units for quantities
- Make the units make sense
- Capture operational causal structure
- Revise, refine, expand, clarify, revise, revise, ...
- Tell insightful stories with evolving diagrams

Thoughts about Process

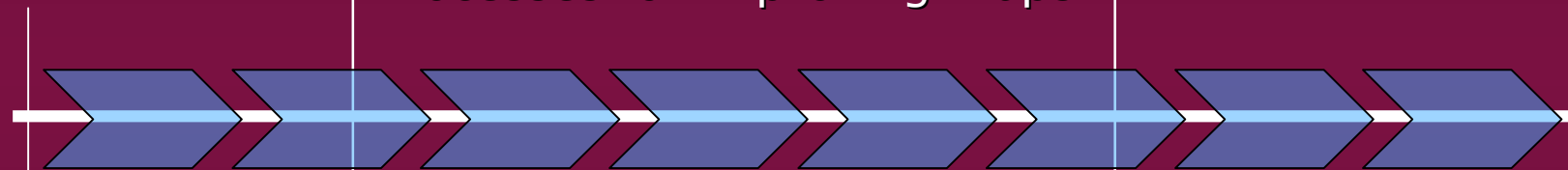
- Move toward a “formal” map -- a map of such extreme causal, operational, and insightful clarity that it could be quantified and simulated
- But stop when the process has served its purposes

What I'm still learning from Barry:

We must get good at processes for map and model *improvement*, get explicit about them, and get good at teaching them.

Various
starting
places

Processes for improving maps:



**Informal
maps**

- Stock-and-flow thinking
- Dimensional consistency
- Extreme causal clarity
- Operational thinking
- Nonlinear thinking

**Formal
maps**

**Formal
models**

Various
kinds

What are we striving for?

- The ability to work together to solve real world problems
- The willingness to examine and change one's own assumptions and conclusions
- Openness to the mental models of others
- Patience and persistence in problem solving
- The willingness to be wrong and to learn from mistakes
- An acceptance that there is often no right answer

What are we striving for?

- Seeing oneself as an integral part of a larger system with a shared responsibility for the common good
- Empowerment
- An extended time horizon
- An ability to relate the past to the present and the present to the future
- An internalization of all these principles that informs actions and interactions with others