Lesson 1 Systems Theory

October 28, 2019 3:21 PM

Intro

- Cartesian thinking (reducitonist perspective)
  - assumes that problems of larger system will be addressed if all problems of system's constituent parts are solved
  - not always the case
  - makes it difficult for urban transportation engineer to effectively respond to the call to move away from fossil fuels as and energy source
- now know that a new way of thinking (in terms of complexity) is required to manage large complex and changing systems
- systems approach enables analysis of a sub-system while keeping an eye on the context in which the sub-system is situated (ex. social, economic, political etc.)
- Complexity defines reductionist perspective of breaking a larger problem into constituent parts, solving problems associated with the constituent parts, managin the larger system
- consider self-organizing behaviour and influence of feedback loops within systems and interdependencies between systems
- the systems perspective changes the way we engage in engineering decision making

Simple or Complex

- system defined as group of componenets interconnected such that they work together for a common purpose
  - can identify discrete elements/componenets/parts
  - can determine if elements affect eachother
  - do elements together generate an effect that is different from each effect of the individual element
- **Simple systems**
  - whole is equal to sum of its parts
  - can be modelled using physics, calculus, etc.
- **Complex system**
  - whole is greater than sum of parts (ex. body, brain, tree, education, etc.)
  - complexity science, study of complex systems, modelled by using post-normal science techniques

Mental Models

- we understand the world through mental models that we subconsciously create in our brains
- system is a type of mental model
- systems thinking is a way fo viewing the world as interplay between multiple overlapping and/or layered systems

Systems Thinking

- world-view/perspective that focuses on observing relationships between things, context of relationships and finding recurring paterns within and between these relationships
- being aware of the interplay between a variety of different systems at different scales and different themes

Quiz

- What thinking framework is the foundation of traditional engineering practice?
  - Reducitonism
- Which of the following options DOES NOT describe a system

    - A handful of toothpicks
    - XXX A wooden table
    - Several marbles on a flat surface
- Which of the systems below are simple systems?
    - A wooden table
    - a pinball machine
    - a gearbox
    - OOO the international space station

Lesson 2 Complexity Science and Resiliency

October 28, 2019 4:27 PM

Synopsis

- **Complex system properties**
  - Complex collective behaviour
    - large networks of individual components
    - had to predict changing of patterns
  - Signalling and information processing
    - produce and use info and signals from internal and external environments
  - Adaptation
    - All complex systems adapt, their behaviour changes to improve their chances of survival or success
- self-organizing systems: organized behaviours arise without internal or etxternal controller
  - macroscopic behaviour = emergent
- How does behaviour at one scale give rise to behaviour at larger scale?
- complex system can be resilient or not resilient

Resilience

- we need to built resilient systems in our society
- our society is built on a brittle system reliant on technology
- Resilient in a complex system protects its nested group of interacting sub-systems from devastating disturbances
- Brian walker tells us that to maintain a resilient system, the system must always be experimenting with the boundaries of what kind of disruption the system can and cannot handle

The Adaptive Cycle

- Adaptive cycle: simple model resiliency theory offers to describe behaviour of complex system by the Resiliency Alliance
- 4 phases:
  - **Rapid growth (r)**
    - Social, economic, or environmental resources are abundantly available and facilitate rapid growth
    - fast phase
  - **Conservation (K)**
    - Resources are no longer plentiful, slowing growth
    - slow phase, little capacity to change, system less flexible and vulnerable
  - **Release/Disturbance (Ω)**
    - distrubance causes system to collapse
    - quick, chaotic phase
  - **Reorganization (α)**
    - System may reorganize into a different structure after collapse, new entities formed and innovation achieved
    - quick phase

Example of Adaptive Cycle

- **Adaptive cycle of Forest ecosystem**
  - Rapid growth: quick growing seedlings, nutrients in ground, rapid growth
  - Conservation: growth slows as trees reach full height, slower growing trees species develop, fewer nutrients

    - Release/Disturbance: vulnerable due to age and lack of agility, forest fire or bug infestation causes forest to collapse
    - Reorganization: Trees fall and rot, release nutrients and seeds take root, different species grow

Quiz

- **3 Common properties in Complex systems**
    - Complex systems consist of large networks of individual elements that each follow relatively simple rules with no central control or leader.
    - Information and signals from both internal and external environments are used and produced by complex systems.
    - Complex systems change their behaviour through learning or evolutionary processes.
- **Emergent Behaviour**
    - Behaviour that is self-organized without a controller or leader. It is the result of system components following a simple set of rules and it is often unpredictable.
- **Adaptive behaviour that involves humans**
    - The Adaptive Cycle of Vancouver's Water Supply
        - Vancouverites pay for the provision of clean water (a resource) as part of their property taxes, with one fee per residential user paid, regardless of the volume of water consumed.
        - Water remains plentiful (conservation), however Vancouver's population continues to grow.
        - A very dry winter, spring and summer could spark a severe water shortage in Vancouver (disturbance)
        - resulting in the implementation of a new water management framework with conservation and user-pay-per-volume as the new norm (reorganization).

Lesson 3 Systems Thinking in Action

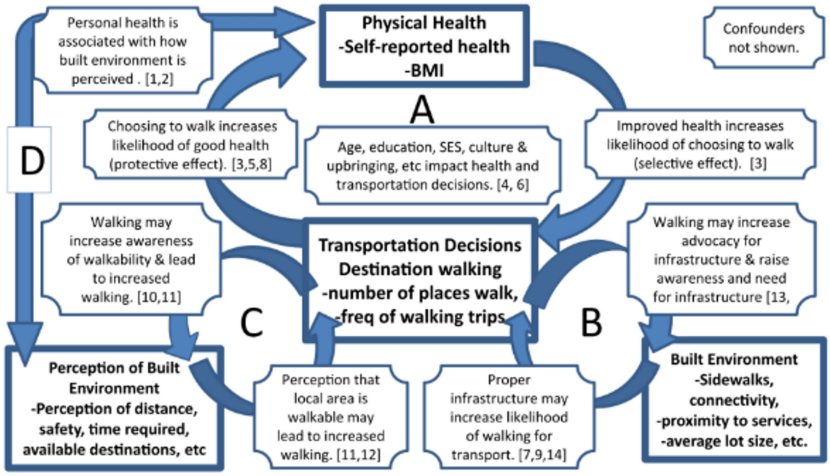
October 28, 2019 5:11 PM

Transportation and Health

- people exposed to elements of walkability like sidewalks, connected streets, etc may not be influenced by individual element to become more active, they are likely to partake in active living bc of overall improvements to built environment
- while individual elements within a system may not influence behaviour, the group of elements together may interact in a borader pattern or arrangement to trigger a desirable outcome
- it is the group of transportation system elements existing within a walkable environment (rather than each element on its won which influences the activity level of individual people

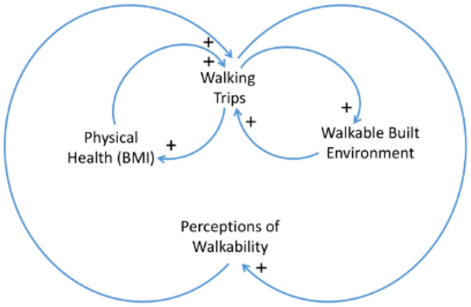
Modelling Built Influences

- illustrates interactions between built environment and human health includes feedback loops marked A B C D
- ex. feedback loop A illustrates choosing to walk increases likelihood of good health, improved health increase the likelihood od a person choosing to walk



Causal Loops

- represent systems model
- pos arrow relationship: decline in cause = decline in effect
- neg arrow relationship: decrease in cause = increase in effect



Quiz

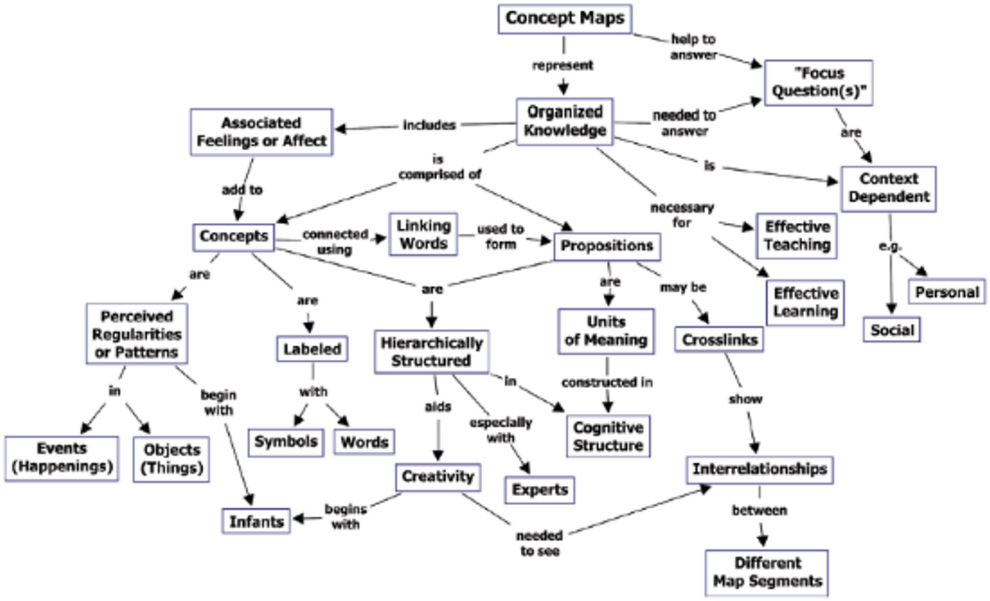
- Given the definition of a system, which of the following items are the components
  - Individual's transportation decisions
  - Components of the built environment
  - Perceptions of the built environment
  - Physical health of individuals
  - XXX Age, education, culture, etc. of individuals

Lesson 4 Concepts and Causes

October 28, 2019 6:13 PM

Concept Maps

- **Characteristics**
  - Concept
    - perceived regularity in events or objects/records of events or objects designated by a label
  - Linking words
    - Propositions are statements about some object or event in the universe either naturally occurring or constructed.
    - contain two or more concepts connected using linking words or phrases to form meaningful statement
  - Concept hierarchies
    - concepts represented in hierarchical fashion with most inclusive, generated concepts at top of map, and more specific, less general concepts arranged hierarchically below
    - depends on context in which knowledge is being applied or considered
    - map in reference to particular question we seek to answer, focus question
  - Cross-links
    - links between diff segments/domains of concept map
    - help see how concept in domain related to concept in another

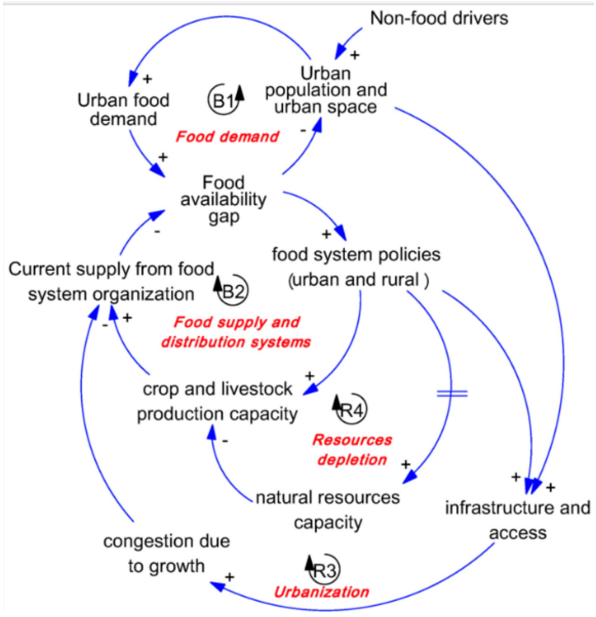


Creating Concept Maps

- Find focus question, specifies problem or issue, creates context
- create raneked list of key concepts, 15-25, start with most general, then more specific
- preliminary concept map, use IHMC CmapTools
- Add cross links, between concepts in different areas of knowledge on map, help illustrate how these areas are related to one another

Causal loop diagrams

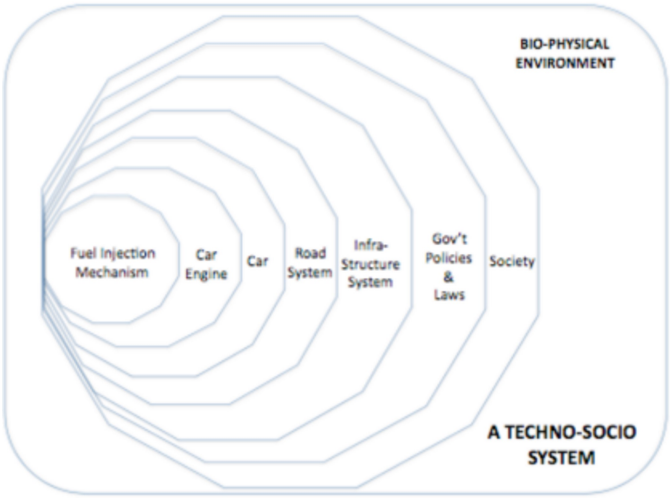
- feedback loops in CLDs reinforcing or balancing
- double slash across arrow = causal relationship between "food supply policies" and "natural resources capacity", significant lag time between initial change in first var


Non-food drivers
Urban food demand
B1
Urban population and urban space
Food demand
Food availability gap
food system policies (urban and rural)
Current supply from food system organization
B2
Food supply and distribution systems
crop and livestock production capacity
R4
Resources depletion
natural resources capacity
infrastructure and access
congestion due to growth
R3
Urbanization

Lesson 5 Built and Natural Systems

October 28, 2019 6:44 PM

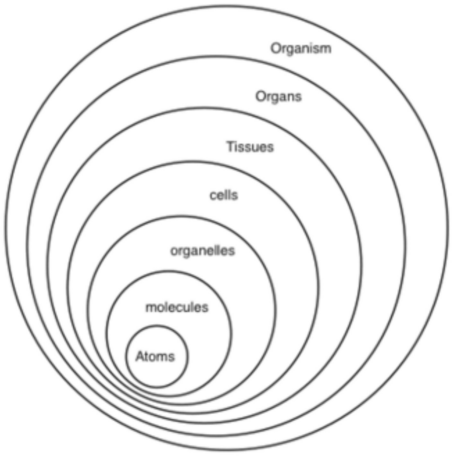
- ex. large scale system made of 7 smaller systems



- decisions made at one scale can have unintended consequences at a different scale

Bio vs Techno

- nestedness exists in nature
- ecosystem is a natural and highly complex system consisting of functioning subset of biological organisms and physical environment occupied/used by same subset



Urban Ecology

- study of ecology within cities, study of ecology of cities
- by considering ecology of city as a whole, start to consider the dynamic feedbacks between systems nested within urban ecology