

Playing in the bathtub: how we think about the bathtub metaphor

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1. ABSTRACT

The bathtub metaphor is a fundamental framework used for teaching systems thinking and system dynamics concepts. Over the past two decades, a number of studies have investigated student misconceptions of systems thinking concepts, yet little progress has been made in understanding why students struggle with fundamental stock and flow concepts. One possibility is that the bathtub metaphor is not adequately understood and is indeed used differently across the systems thinking community. The purpose of this extended abstract is to share work in progress around this problem, and to prompt discussion around this topic with systems thinking educators in the Asia-Pacific region.

2. BACKGROUND

It is commonplace for the systems thinking (ST) community to view the construction of knowledge as the development and iteration of mental models (Serman, 2000). Mental models are used by individuals to interpret the world around them, and provide a framework for thinking, understanding and learning. Hence, their study is central to building effective learning environments.

In the context of systems thinking, mental models are heavily associated with explaining causal logic: that is, the way that simulated models *should* behave. When a model behaves in unexpected ways, it is an opportunity to challenge the mental model which created the model and to learn through this process.

Many studies have taken place over the last two decades in the field of system dynamics designed to interrogate the mismatch of mental models and actual dynamics of system dynamics concepts. These have most notably been through graphical integration and differentiation tests (Booth Sweeney and Serman, 2000; Serman and Booth Sweeney, 2002, Kapmeier, 2004; Serman, 2008), multiple choice, graphical estimation and training tests (Serman and Booth Sweeney, 2007; Cronin et al, 2009; Serman 2010) and various cover story

tasks (Cronin and Gonzalez, 2007; Brockhaus et al, 2013; Sedlemeier et al, 2014). However, it is clear from these studies that there is no 'silver bullet' to help novice system dynamicists rapidly enhance their mental models of system dynamics concepts.

3. COGNITIVE SCIENCE AND THE BATHTUB METAPHOR

Through developments in cognitive science, it has become clear that human thought occurs through underlying metaphorical constructs embedded in language.

Human conceptual systems are metaphorical in nature and involve an imaginative understanding of one kind of thing in terms of another.

- Lakoff and Johnson (2003, p. 194)

Cognitive science shows that conceptual metaphors have an underlying organisation of categories and relationships, called a schema, allowing for a deeper analysis of this construct. In a conceptual metaphor, concepts from one context (the source domain; here, the bathtub) can be mapped into another context (the target domain; here, systems thinking concepts). The mapping between the source and target domains is necessarily partial for the metaphor to make sense for its application: the source domain is *like* the target domain. However, the use of vocabularies between the source and target domains can highlight or obscure concepts and in turn change the way that concepts are understood (Lakoff & Johnson, 2003). Hence, careful mapping between domains can enable people to think through cause-and-effect structures in the source domain without requiring expert knowledge in the target domain.

This, in essence, is the power of the bathtub metaphor when learning systems thinking concepts.

The bathtub is an instance of the well-established container metaphor. The container metaphor, describes the construct where objects (things, people, ideas, words, et cetera) are placed into and taken out of a container, and is fundamental to

human cognition. The container schema logic makes sense because of our physical experience with containers. Objects can be put in containers and taken out of containers, and because of our metaphorical understanding of ‘things’, so can abstract concepts. Phrases such as *I am in trouble* or *I got out of trouble* make sense because of the underlying container schema logic which correspond to our physical experience with, and our shared *a priori* understanding of, containers.

4. PROBLEMATISING THE BATHTUB METAPHOR

A model boundary chart can be used to explicitly describe the scope of a given system of interest, and can reveal the underlying assumption of the modeller (Sterman, 2000, p. 98). In Table 1, a model boundary chart has been constructed to show the basis of a simple model in the bathtub metaphor.

Table 1. An example model boundary chart for a basic bathtub metaphor model

Endogenous	External	Exogenous
water; bath volume; rates of flow through taps; rate of flow through drain	desired water level	price or availability of water; temperature of water; people; toys; bubbles; gravitational constant; alternative means of water addition; alternative means of water removal; evaporation rate; bathtub material and surface finish

Considering the endogenous factors in Table 1, a conceptual mapping can be constructed to relate the conceptual source domain (the bathtub) to a conceptual target domain (the systems thinking concept). Newell (2012) demonstrates the mapping. For example:

Conceptual source domain: a bathtub

The water in the bathtub

Corresponds to:

Conceptual target domain: a systems component

An accumulation, a ‘stock’, a variable that measures the state of the system component at time ‘t’

This treatment can be made to all of the components within the bathtub metaphor. Hence, the bathtub metaphor only makes sense to novice systems thinkers because of the concrete and largely universal experience of using a bath.

One confounding factor is the ambiguity of or addition of features related to a bathtub, which can obscure the mapping between the source and target domains. For example, when aspects described in the exogenous category of Table 1 are included in the conceptual mapping, the bathtub metaphor is modified and perhaps even confused. Consider the conceptual mapping of a factor such as the temperature of water. This lived experience of an

element in the source domain can lead to misunderstanding in the target domain (the systems component).

There have been attempts to modify the bathtub metaphor to account for physical inconsistencies in the source domain, such as gravitational effects, by the replacement of taps and drains with pumps (see Sedlmeier et al, 2014). Alternative metaphors have also been proposed, such as using the iconic rusty water tank (see Dyball & Newell, 2014), which brings with it a different set of values associated with environmental conditions: an overflowing water tank is a sign of prosperity, whereas an overflowing bath is a sign of imminent trouble(!)

Further, cover stories—such as the department store task, gathering crop yields or determining investment of cash—provide a plausible parallel mapping between the bathtub metaphor and the systems component. Although the components in cover stories can be mapped to the systems component, the cover stories add further mapping and potential to confuse relationships due to the mapping of the conceptual metaphor.

5. WORK IN PROGRESS DISCUSSION

A comprehensive study of how the SD community maps concepts between the source and target domains of the bathtub metaphor is being undertaken. It is hypothesised that it is a limitation of the bathtub metaphor itself is a contributing factor to the misunderstandings in systems thinking uncovered in recent decades by the system dynamics community. This work involves researching the use of instances of the bathtub metaphor by SD practitioners to propose a comprehensive mapping between the conceptual source and target domains.

As the bathtub metaphor is an essential concept used in developing the mental models of our novice system dynamicists, this work has the potential for improving understanding of how we communicate concepts fundamental to the discipline.

6. REFERENCES

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