Models of Models
by Hugh Dubberly

Editor’s note:
This forum presents models relevant to interaction design and service design. It describes the models, how they might be used, and why they matter. It also describes the models’ origins and contrasts related models.

In its first year, forum articles described models of:
- Innovation process
- Design process (Analysis-Synthesis Bridge)
- Customer experience cycle
- Learning in design and product development
- The trend from a mechanical to a biological frame in design (era analysis)
- Design research types (map)
- Interaction types (taxonomy)

However, none of the articles presented a model of models. We correct that oversight here.

Models are ideas about the world—how it might be organized and how it might work.
Models describe relationships: parts that make up wholes; structures that bind them; and how parts behave in relation to one another.

For example, the sun rises in the east, moves across the sky, and sets in the west. Or the earth orbits the sun.

Models support communication and learning. Models help bridge the gap between observing and making, between research communities and design communities [1]. Models are especially important in interaction and service design.
Making Sense and Guiding Action
Models help us make sense of things. Stafford Beer wrote, “Now in trying to account for the behavior of a complicated system, the scientist has first to represent it in the formal terms he knows how to manipulate.... The formal representation of the system that he builds is called a model. This model is something different than the diagrams that are drawn.” [2] Alan Kay noted, “Models are our voodoo dolls. We do most of our thinking in models.” [3]

Models begin with things or events that we observe. We want to describe or explain what we see. Pieces fit together; patterns emerge; we posit causes and effects. Under this frame, evidence leads to models.

Learning As Forming and Reforming Models
If we are “present and engaged” (that is, paying attention) and yet we have an accident or make a mistake, the cause may be some defect in our models. That is, our models suggested one outcome, but we have found another. The difference between expectation and outcome creates an opportunity for learning.

Learning involves forming models and reforming them based on feedback. We observe some behavior in our environment; it suggests models, which we use to predict future behavior and guide our actions. Additional observations provide feedback, which helps us revise and refine our models. We learn.

When outcomes do not match our predictions, we have two choices:
1) Reject the data
   - Were measurements inaccurate?
   - Was the test procedure flawed?
   - Was the reporter biased?
2) Accept the data
   - Is it relevant to our model?
   - Is it a special case? Meaning our model is less useful at the extremes or our model needs refinement or extension,
   - Was previous data inaccurate or insufficient?
   Meaning we need to revise our model.

Under this frame, we modify our models based on the results of our predictions—we subject them to feedback.

Chris Argyris wrote, “Although people do not [always] behave congruently with their espoused theories [what they say], they do behave congruently with their theories-in-use [their mental models].” [4] Under this frame, models lead to action.
We evolve our models as we test their predictions.

Learning involves:

- Creating new models

- Revising existing models
  - Extending a model so that it corresponds to more observations (broadening)
    
    *For example, Ptolemy introduced cycles within cycles to account for the retrograde motion of Mars.*

  - Refining a model so that it more closely corresponds to observation (deepening)
    
    *For example, Kepler found that Brahe’s observations showed that the planets follow an elliptical (not circular) path around the sun.*

- Generalizing models—reframing a model of a specific event as a model of a more general set of phenomena

  *For example, the shift from the Ptolemaic to Copernican model is an example of a general case that recurs throughout the history of science as one important model gives way to another. Kuhn named this a “paradigm shift.”*

- Identifying model primitives—finding patterns that recur across many models, often based on fundamental rules of geometry or topology

  *For example, the earth orbiting the sun is a special case of a more general model of satellites orbiting primary bodies, which describes other cases such as the moon orbiting the earth or suns orbiting the center of a galaxy. A system in which one element revolves around another is a fundamental pattern—a “primitive” or building block of models.*

We use models and learn through them, not only as individuals but also as groups. Learning takes place on at least four scales:

1) Individual
2) Work-group (or play team), which is composed of individuals
3) Organization, which is composed of work-groups
4) Culture, which is composed of organizations
Learning—forming and reforming models—begins with individuals. It can expand to work-groups, organizations, and even entire cultures. That is, a model may be highly idiosyncratic, rarely shared with others. Or it may be highly conventional, widely shared by others.

At each scale, three levels of process are at work:

1) Primary—the activity at hand; understood through models

2) Second-order—direct learning (and designing); improving primary processes, that is, refining models of primary processes

3) Third-order—meta-learning (learning about learning); improving second-order processes, that is, improving models of learning and models of models

Passing models from one generation to the next is a responsibility of teachers and managers. Models are what students take away from school and what young people take away from early jobs. Models are what you remember after leaving.

Peter Senge noted that developing and sharing models is fundamental to “learning organizations.” He suggests that a leader’s role is to improve both his or her own mental models and those of the organization—to test and add to the mental models of others [5].

Design is a young profession; design practices that operate as learning organizations are rare. Typically, models remain implicit. Students learn by watching teachers, managers, and colleagues. Universities, professional organizations, and design practitioners have much opportunity to improve the way designers learn—to develop systems for forming and reforming models of design processes.

Limits and Costs
Earlier, I described observation shaping models; but models also shape what we see—what we let ourselves notice. Our models tell us what is important, what counts, what to look for. Peter Senge wrote, “Models [are] so powerful in affecting what we do...because they affect what we see. Two people with different mental models can observe the same event and describe it differently, because they’ve looked at different details.” [5]

Under this frame, models also lead to evidence.

In a similar way, models already shared within an organization may limit its ability to see new evidence, understand changing situations, or act in its own interest. Old models often resist new ones and inhibit learning. That’s why organizations need to expose the fundamental models that guide them and periodically challenge those models.

Creating or revising a model is meta-activity, taking us outside the primary activity in which we were engaged. It requires attention, energy, and time.

But a new or improved model may pay dividends; it may reduce accidents or other unexpected outcomes, or it may make an individual or group more competitive. In this way, forming and reforming models may “pay for itself.”

Sharing models may reduce group costs and thus create value. But the cost of adopting new models can also inhibit their spread. Adoption requires value that clearly outweighs cost.
Agreement and Understanding
Models are closely tied to stories. We explain models by telling stories, and when we tell stories, listeners form models—mental pictures of the actors, how they are related, and how they behave.

Models are explained by stories; stories build models.

Models and stories are tools for thinking.

- Are explained by
- Create

models and stories are tools for discussion

Shared models support discussions. They are examples of what Susan Star called “boundary objects,” artifacts that enable discourse at the boundaries between communities of practice [6]. By sharing our models, we may be able to confirm where we agree—and discover where we disagree.

Models provide a basis for shared understanding, agreement, and group action. They also build trust and enable collaboration.

Agreement begins with individual understanding—forming our own models. Through conversation, we begin to understand each other’s models—to form models of the other’s models. We compare our model with the other’s model. Are our models congruent? Do we agree? And then, do we agree that we agree? If so, we have reached “an agreement over and understanding.” We have a basis for trust, collaboration, and action [7].

Shared models are the basis for understanding, agreement, and action.
Models in Design
As designers increasingly focus on systems and communities of systems, we need to improve our modeling skills.

Without modeling, system design is not possible. Often service systems and computer-based applications are partly hidden or invisible, or they stretch across time and space and cannot be seen all at once or from a single vantage point. In such cases, models must stand in for systems during analysis, design, and even operation.

Using models, designers can unify otherwise separate artifacts and actions. Interaction models unify interface widgets. Service models unify customer touch points. Brand models unify messages. Platform models unify individual products.

Drawing has long been an essential skill for designers and the heart of design education. Bill Buxton, Dick Powell, and others assert that “drawing is the essence of design.” [8] Are they correct? Perhaps—if designers focus on objects. But when attention turns to systems, modeling becomes the essence of design. Design education and practice must adapt to this changing reality.

Von Bertalanffy wrote, “The advantages and dangers of models are well known. The advantage is in the fact that this is the way to create a theory—i.e., the model permits deductions from premises, explanation and prediction, with often unexpected results. The danger is oversimplification: to make it conceptually controllable, we have to reduce reality to a conceptual skeleton—the question remaining whether, in doing so, we have not cut out vital parts of the anatomy. The danger of oversimplification is greater, the more multifarious and complex the phenomenon is.” [9]

Keeping in mind the multifarious and complex nature of design—and the attendant dangers—we must bring more rigorous modeling to our work.
Sharing a model may also change it.

All these feedback loops, and more, act simultaneously—shaping and reshaping our models.
Questions to Ask When Making Models

For any set of observations (or system), we may imagine many models.

And for any (mental) model, we may imagine many representations.

What should the model attempt to predict? What is in the system, and what is not? Who or what are the actors? What resources do they use? How do they affect one another? What level of abstraction or degree of granularity is appropriate?

Enlist others to work with you. Begin with discussion. Use a whiteboard to record comments. Record the whiteboard in photographs.

Write a working title for the model.

Create quick, low-fidelity sketches. Identify the system’s elements and write the name of each on a Post-It note. At the beginning, don’t worry about having too many elements or the wrong elements. Editing comes later.

Arrange the Post-It notes to describe the system’s structure. Group similar elements. Place elements that often interact near each other. Avoid repeating elements. Label connections.

Review your proto-model to see which model primitives or patterns it includes. Are these appropriate, or would others be better? Does the proto-model build on or suggest already established or generalized models?

Revise your proto-model.

Present the proto-model to your constituents; tell them the model’s story. Observe their reactions; ask for feedback; reflect on what was easy or difficult to explain. Record these results, and create an “issues” list for debugging the model.

Revise. Increase fidelity and detail as appropriate. (Determining what’s appropriate becomes easier with practice—as your model of modeling grows.)

The quality of models and representations increases with iteration. So: Iterate.
When Judging Visual Representations, Consider Five Primary Criteria:

1) Fit

*Is the representation congruent with the model?*
Do representation and model have similar structures?
Are all the elements in the model explicit in the representation?

2) Least Means

*Could the model be represented in a simpler way?*
What can be removed without changing the meaning? (Remove decoration.)
Could conventional symbols or other standard patterns make reading easier?

3) Consistency

*Are the means of representation consistent?*
Similar forms should represent similar functions or similar content. Likewise, similar functions or similar content should be represented by similar forms.
Are all elements and their connections labeled?

4) Contrast

*What about the model should appear to be most important?*
Does the most important thing appear most important? (Not everything is equally important. Important elements of the model should stand out in the representation. One way to achieve contrast is through scale, making more important items larger than less important items.)

5) Hierarchy

*How do the elements of the system appear to fit together?*
Is the structure of the system clearly visible?
Do we know where to look first?
Can we find a clear path through the model?

The final test of the model (and representation) is with the audience.

*Does the audience understand it?*
*Do they agree with it?*
*Do they agree that they agree?*
*Will they act on it?*

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When Judging (Mental) Models, Consider Four Basic Criteria:

1) Fit

*How does the model fit the evidence?*
Is our evidence relevant?
Is it reliable?
Is it sufficiently granular? (depth)
Do we have enough evidence to draw meaningful conclusions? (breadth)
Are the elements of the model necessary and sufficient?
Are the elements of the model “MECE”—mutually exclusive and collectively exhaustive?

2) Least Means

*Is there a simpler way to explain the evidence?*
Given two models explaining the same evidence, Occam told us to prefer the simpler.

3) Consistency

*Is the model internally consistent?*
Is it free from contradiction?

4) Predictive Value

*What predictions does the model make?*
Are our model’s predictions consistent with later observations?
Do the model’s predictions help us make decisions that might have been more difficult without them?
Sidenotes


