Models of models

Hugh Dubberly — Dubberly Design Office — hugh@dubberly.com

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.

Figure 1
Models are ideas about the world—how it might be organized and how it might work.

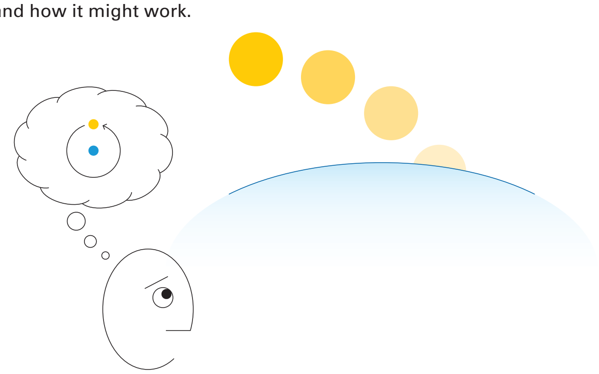


Figure 2
A representation of the Ptolemaic model of the "world system" —a geo-centric view. A representation of the Copernican model of the "solar system" —a helio-centric view.

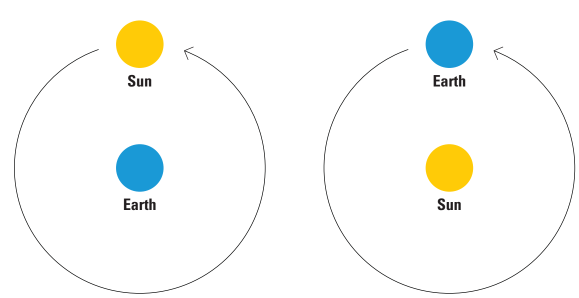


Figure 3
Observations can be a source of new models.

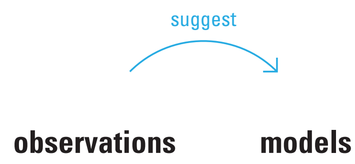
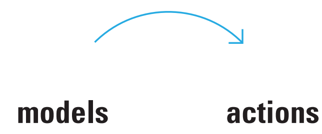


Figure 4
Our models guide our actions.



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 observations new models action 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.

Models are conjectures—hypotheses. They are not formed by deduction or induction but by abduction—inferring the most likely story to explain the evidence. Abduction is the creative heart of science, engineering, and design. Its mechanism remains unknown—though preparation and persistence may aid the process. Models are not the special province of science. We use them all the time. Models help us recognize new situations as similar to others we have encountered. Without a model, recognizing the similarities might be difficult. Models also help us predict likely futures: what actions other actors may take, consequences of those actions, and what actions best respond to threats or most efficiently help us pursue our goals. Armed with our models' predictions, we act accordingly.

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.

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 observations new mo 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.

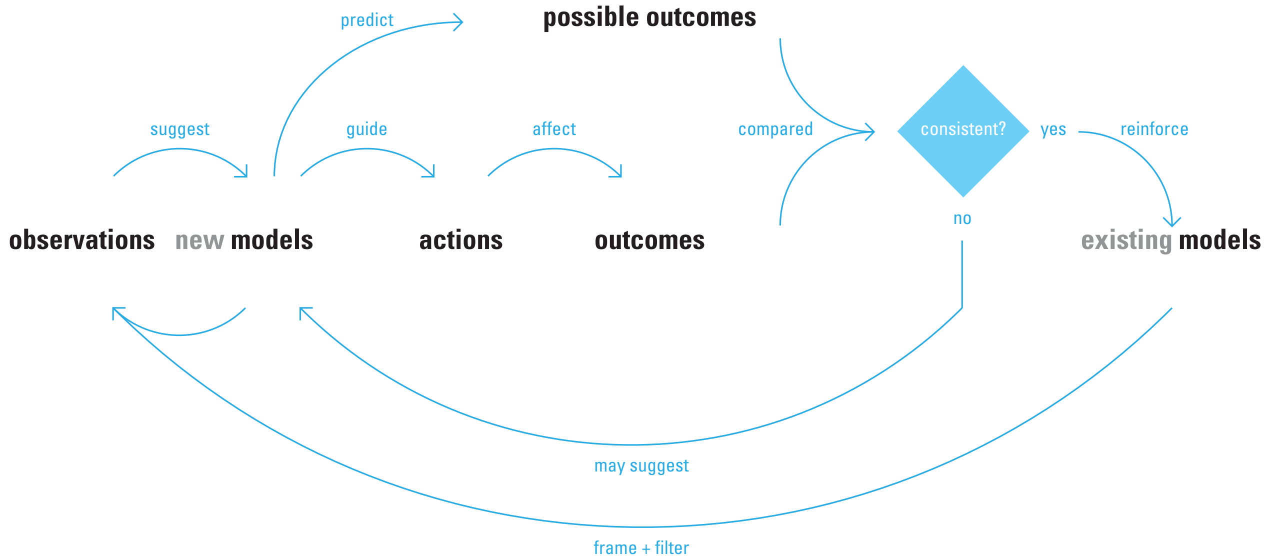
When outcomes do not match our predictions, we have two choices:

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.

Figure 5
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 orbitting 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 (individual through culture), 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."[6] 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.

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]

Figure 6
Our models affect what we see.

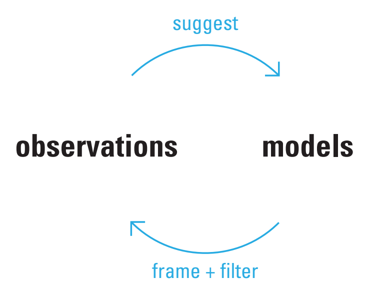


Figure 7
Models are explained by stories; stories build models.

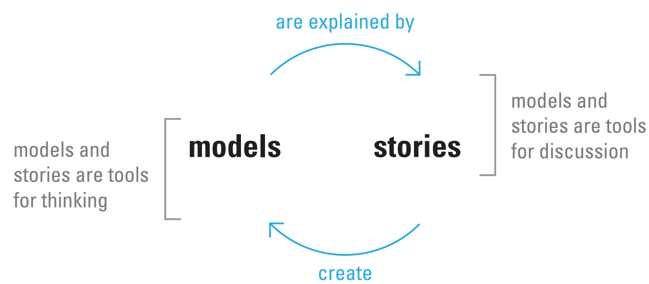
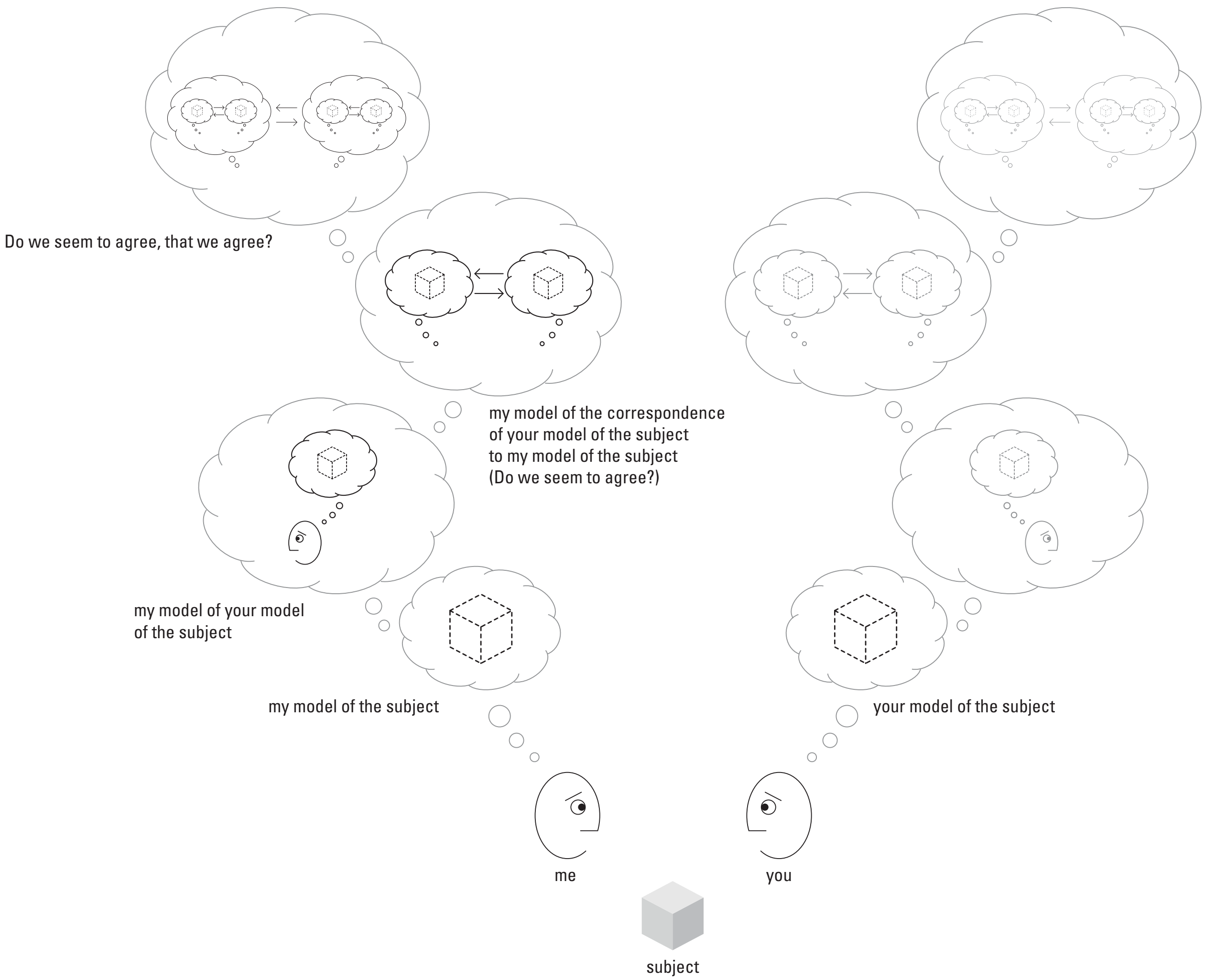


Figure 8
Shared models are the basis for understanding, agreement, and action.



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.

Figure 9
Observation may suggest models, but models also frame and filter observations.

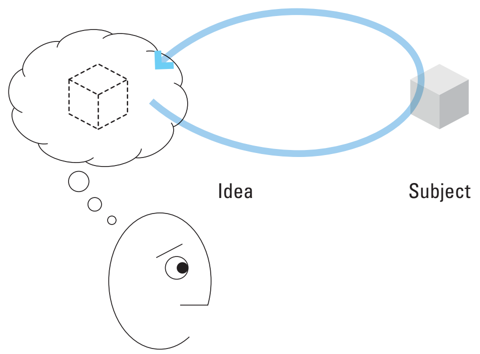


Figure 10
Thinking about how to explain our observations may lead us to think of alternatives or related ideas.

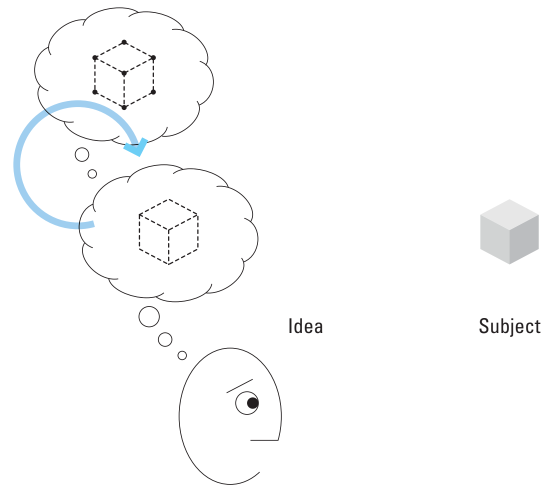


Figure 11
The process of representing an idea may change the idea itself.

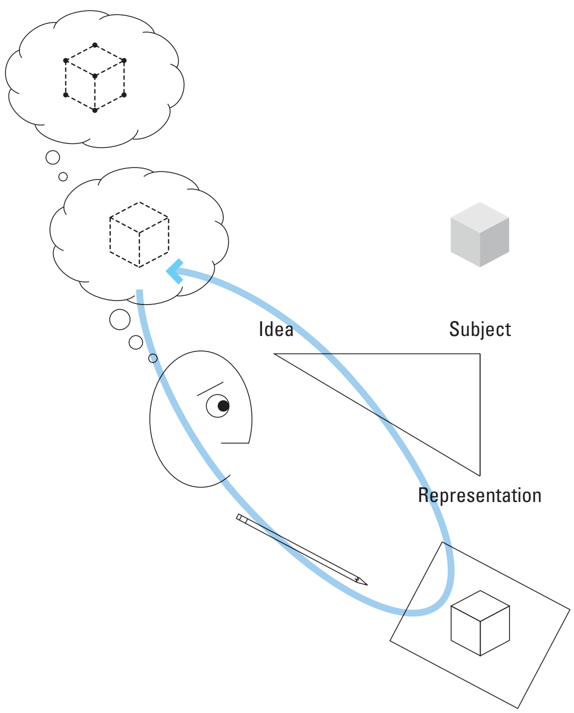


Figure 12
Sharing a model may also change it.

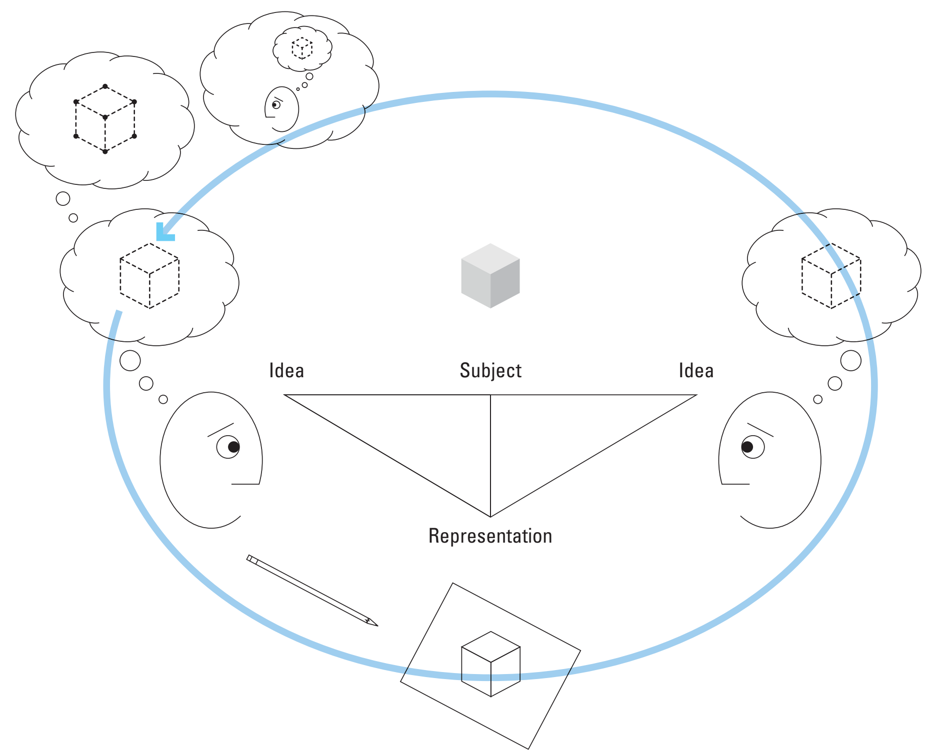
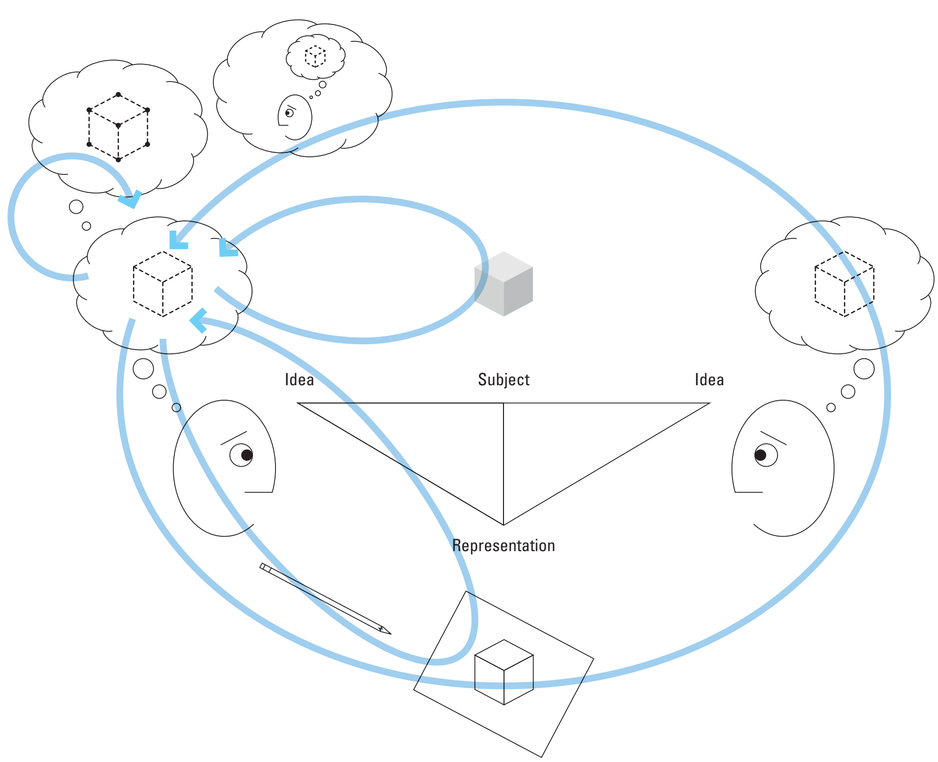


Figure 13
All these feedback loops, and more,
act simultaneously-shaping and reshaping our models.



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 processes lead to good models?
What processes lead to good representations?

How do we recognize a good model?
How do we recognize a good representation?

All models have a purpose and serve constituents. Models have a point of view; and they advocate it. Models are always political.

Acknowledge the subjectivity of modeling: Considering your constituents. Speak with them to learn their needs and their views of the system (situation).

Directly observe the system; record your observations. If you are modeling a system that does not exist, observe similar systems.

Constituents' goals and system observations form the criteria against which we judge both model and representation.

Why are we making a model?
What decisions or actions will it support?
Who are the constituents for the model?
What are their goals?
How can the constituents be involved in the modeling process?
How will decisions about the model and representation be made?

Models are not objective. They leave things out. They draw boundaries between what is modeled and what is not; between the system and its environment; and between the elements of the system.

Framing a system—defining it—is editing. What we think of as natural boundaries, inside and outside, are somewhat arbitrary. The people making the model choose what boundaries to draw and where to draw them. That means, they have to agree on the choices.

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 white-board to record comments. Record the white board 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; 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 (Mental) Models, Consider 4 Primary 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, Ockham 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?

When Judging Visual Representations, Consider 5 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?

Endnotes

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