

Mental Models: How We Map Reality

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A mental model is an explanation of someone's thought process about how something works in the real world. It is a representation of the surrounding world, the relationships between its various parts and a person's intuitive perception about their own acts and their consequences. Our mental models help shape our behaviour and define our approach to solving problems (akin to a personal algorithm) and carrying out tasks.

Overview

A mental model is a kind of internal symbol or representation of external reality, hypothesized to play a major role in cognition, reasoning and decision-making. Kenneth Craik suggested in 1943 that the mind constructs "small-scale models" of reality that it uses to anticipate events.

One example is provided in the following description from Richard Feynman:

I had a scheme, which I still use today when somebody is explaining something that I'm trying to understand: I keep making up examples. For instance, the mathematicians would come in with a terrific theorem, and they're all excited. As they're telling me the conditions of the theorem, I construct something which fits all the conditions. You know, you have a set (one ball) - disjoint (two balls). Then the balls turn colors, grow hairs, or whatever, in my head as they put more conditions on. Finally they state the theorem, which is some dumb thing about the ball which isn't true for my hairy green ball thing, so I say, 'False!'

Jay Wright Forrester defined general mental models as:

"The image of the world around us, which we carry in our head, is just a model. Nobody in his head imagines all the world, government or country. He has only selected concepts, and relationships between them, and uses those to represent the real system."

In psychology, the term "mental models" is sometimes used to refer to mental representations or mental simulation generally. At other times it is used to refer to mental models and reasoning and to the mental model theory of reasoning developed by Philip Johnson-Laird and Ruth M.J. Byrne.

History

The term is believed to have originated with Kenneth Craik in his 1943 book *The Nature of Explanation*. Georges-Henri Luquet in *Le dessin enfantin* (Children's Drawings), published in 1927 by Alcan, Paris, argued that children construct internal models, a view that influenced, among others, Jean Piaget.

Philip Johnson-Laird published *Mental Models: Towards a Cognitive Science of Language, Inference and Consciousness* in 1983. In the same year, Dedre Gentner and Albert Stevens edited

a collection of chapters in a book also titled *Mental Models*. The first line of their book explains the idea further: "One function of this chapter is to belabor the obvious; people's views of the world, of themselves, of their own capabilities, and of the tasks that they are asked to perform, or topics they are asked to learn, depend heavily on the conceptualizations that they bring to the task." (See *Mental Models* (Gentner-Stevens book).)

Since then there has been much discussion and use of the idea in human-computer interaction and usability by researchers including Donald Norman and Steve Krug in his book *Don't Make Me Think*. Walter Kintsch and Teun A. van Dijk, using the term situation model (in their book *Strategies of Discourse Comprehension*, 1983), showed the relevance of mental models for the production and comprehension of discourse.

Mental models and reasoning

One view of human reasoning is that it depends on mental models. On this view mental models can be constructed from perception, imagination, or the comprehension of discourse (Johnson-Laird, 1983). Such mental models are akin to architects' models or to physicists' diagrams in that their structure is analogous to the structure of the situation that they represent, unlike, say, the structure of logical forms used in formal rule theories of reasoning. In this respect they are a little like pictures in the "picture" theory of language described by Ludwig Wittgenstein in 1922. Philip Johnson-Laird and Ruth M.J. Byrne developed a theory of mental models which makes the assumption that reasoning depends, not on logical form, but on mental models (Johnson-Laird and Byrne, 1991).

Principles of mental models

Mental models are based on a small set of fundamental assumptions, which distinguish them from other proposed representations in the psychology of reasoning (Byrne and Johnson-Laird, 2009). Each mental model represents a possibility. A mental model represents one possibility, capturing what is common to all the different ways in which the possibility may occur (Johnson-Laird and Byrne, 2002). Mental models are iconic, i.e., each part of a model corresponds to each part of what it represents (Johnson-Laird, 2006). Mental models are based on a principle of truth: they represent only those situations that are possible, and each model of a possibility represents only what is true in that possibility according to the proposition. Mental models can represent what is false, temporarily assumed to be true, e.g., in the case of counterfactual conditionals and counterfactual thinking (Byrne, 2005).

Reasoning with mental models

People infer that a conclusion is valid if it holds in all the possibilities. Procedures for reasoning with mental models rely on counterexamples to refute invalid inferences; they establish validity by ensuring that a conclusion holds over all the models of the premises. Reasoners focus on a subset of the possible models of multiple-model problems--often just a single model. The ease with which reasoners can make deductions is affected by many factors, including age and working memory (Barrouillet, et al., 2000). They reject a conclusion if they find a counterexample, i.e., a possibility in which the premises hold, but the conclusion does not (Schroyens, et al. 2003; Verschueren, et al., 2005).

Criticisms

Scientific debate continues about whether human reasoning is based on mental models, formal rules of inference (e.g., O'Brien, 2009), domain-specific rules of inference (e.g., Cheng & Holyoak, 2008; Cosmides, 2005), or probabilities (e.g., Oaksford and Chater, 2007). Many empirical comparisons of the different theories have been carried out (e.g., Oberauer, 2006).

Mental models in system dynamics

Characteristics

A mental model is generally:

founded on hardly qualifiable, impugnable, obscure, or incomplete facts

flexible - is considerably variable in positive as well as in negative sense

effects as information filter - causes selective perception, perception of only selected parts of information

compared with the complexities surrounding the world is very limited and even when the scientific model is extensive and in accordance with a certain reality in the derivation of logical consequences of it we are very limited. We must take into account such restrictions on working memory--i.e. well-known rule on the maximum number of elements that we are suddenly able to remember, gestaltismus or failure of the principles of logic, etc.

sources of information, which one can not find anywhere else, are available at any time and can be used. If other routes are possible, which is linked with the fact that it is not always clearly understood by the other, the process of interpretation can be interpreted in different ways.

Mental models are fundamental to understanding organizational learning. Mental models are "deeply held images of thinking and acting." Mental models are so basic to our understanding of the world that we are hardly conscious of them.

Expression of mental models

Three basic forms are used:

Polygons - whose vertices sharing the edge represent related items.

Causal loop diagrams - displaying tendency and a direction of information connections and the resulting causality

Flow diagram - a more appropriate way to express a dynamic system

Mental model in relation to the system dynamics and systemic thinking

The simplification of reality, you create so that we were able to find a sense of reality, seeking to overcome systemic thinking and system dynamics. These two disciplines help us to construct a better coordinated with the reality of mental models and simulate it accurately. They increase the probability that the consequences of how we will decide and act in accordance with how we plan to.

System dynamics - extending our mental models through the creation of explicit models, which are clear, easily communicating and can be compared with each other.

Systemic thinking - seeking the means to improve the mental models and thereby improve the quality of dynamic decisions that are based on mental models

Single and double-loop learning

After analyzing the basic characteristics, it is necessary to bring the process of change mental models, or the process of learning. Learning is a back-loop process and feedback can be illustrated as:

Single-loop learning

Our mental models affect the way we work with the information and determine the final decision. The decision itself changes, but the mental models remain the same. It is the predominant method of learning, because it is very convenient. One established mental model is fixed, so the next decision is very fast.

Double-loop learning

Is used when it is necessary to change the mental model on which our decision depends. Unlike single loops, this model includes a shift in understanding--from simple and static to broader and more dynamic--such as taking into account the changes in the surroundings and the need for expression changes in mental models.

Process of learning:

Feedback process

Single-loop learning

Double-loop learning

Language to express the system of thought

For a description of the structure is used in general to understand the universal graphic symbols, which can describe the structure of generating behavior of any system in time. If individual elements correctly defined, it is possible for a computer in a software model to simulate and interpret the results (e.g. in the form of graphs).

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