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# Cognitive Science for Educators

## Practical suggestions for an evidence-based classroom

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Set and designed by John Catt Educational Limited

*For my wife Leslie, who consistently brings out the best in me.*

# Table of Contents

# Preface

## Goals & Overview

The purpose of this book is to catalyze conversations between cognitive scientists and educators. Of course, this is not a new idea. I adopted this goal from Dr. Robert Glaser, whom I worked with as a PhD student in the Learning Research and Development Center at the University of Pittsburgh. Dr. Glaser believed that cognitive science could inform educational practice. Moreover, he also firmly believed that cognitive scientists could advance their theories by observing what teachers do in the classroom. In other words, there is a virtuous feedback loop between researchers and practitioners. One way to ensure that this conversation continues is to develop a joint vocabulary. Thus, the goal of this book is to introduce the vocabulary from the field of cognitive science to those who are immersed in teaching.

The challenge in reading a book like this is that it is easier to understand when you already know all of the content of the book! Since that isn't typical (otherwise, why would you read a book?), authors must rely on the table of contents as a way to preview all of the information. Educational psychologists have another name for the table of contents. They call it an **advance organizer** [1].

Alternatively, we can organize the ideas covered in a book with a **concept map** [2]. Each concept is linked to other, related concepts. It's been experimentally demonstrated that organizing information hierarchically can help an individual remember huge amounts of information [3]. Figure 1 is an attempt to organize the contents of this book hierarchically, using a concept map.

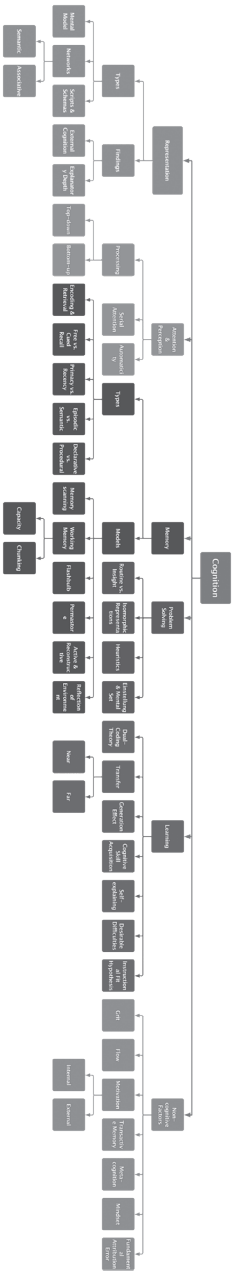


*Figure 1. A hierarchical concept map for the ideas introduced in this book.*

As you can see, we are going to cover a lot of ground. We will start with low-level attentional and perceptual processes, and continue all the way up to a description of the way experts solve problems and see the world.

## Book Format and Features

> *For the things we have to learn before we can do them, we* ***learn by doing*** *them.*
>
> —Aristotle, *The Nicomachean Ethics*

> *Being able to "****go beyond the information given****" to "figure things out" is one of the few untarnishable joys of life. One of the great triumphs of learning (and of teaching) is to get things organised in your head in a way that permits you to know more than you "ought" to. And this takes reflection, brooding about what it is that you know. The enemy of reflection is the breakneck pace—the thousand pictures.*
>
> —Jerome S. Bruner, *The Culture of Education*

Each chapter is broken down into a series of sections, and each section introduces a new vocabulary word. Within a section, there are four parts. Each section opens with an opportunity for **Learning by Doing**. We are going to attempt to practice what we preach by engaging in interactive tasks. The second part is the **main body** of the section. It introduces a concept or finding from cognitive science, and then it illustrates that concept with everyday examples. The third part of a section is my attempt to connect the concept back to education. This part is called **The Classroom Connection**. Finally, each section closes with an opportunity to engage in one of Jerome Bruner's joys of life by **Going Beyond the Information Given**.

Another goal for this book is to have a little bit of fun. Toward that end, sprinkled throughout each of the sections is my humble attempt to connect the content to popular culture. It is my hope that these connections will help attach the new information to what you already know (see the section entitled Associative Networks).

## The Dr. Bob's Cog Blog Connection

The contents of this book were originally published on my blog [4]; however, the blog format has its limitations. Therefore, I decided to reformat the content so that the reader can highlight passages, take notes, and generally interact with the material.

Share and Enjoy! [5]

Dr. Bob

## Going Beyond the Information Given

Nearly all of the original research papers cited in the main body of the text can be found with Google Scholar.

[1] Willerman, M., & Mac Harg, R. A. (1991). The concept map as an advance organizer. *Journal of Research in Science Teaching*, 28(8), 705–711.

[2] Novak, J. D. (1990). Concept mapping: A useful tool for science education. *Journal of Research in Science Teaching*, 27(10), 937–949.

[3] I was introduced to the lovely idea of a hierarchical retrieval structure in the following paper: Bower, G. H., Clark, M. C., Lesgold, A. M., & Winzenz, D. (1969). Hierarchical retrieval schemes in recall of categorized word lists. *Journal of Verbal Learning and Verbal Behavior*, 8(3), 323–343.

[4] Dr. Bob's Cog Blog can be found here: www.drbobscogblog.blogspot.com

[5] I like to close all of my blog posts with this message. I stole it from the *Hitchhiker's Guide to the Galaxy*, and it is one of my feeble attempts to make cognitive science fun. :-)

# REPRESENTATIONS

## Introduction

The mind has a difficult problem to solve. It has to figure out a way to represent information that is both useful and easily stored and retrieved. How is the mind able to solve this problem? It does so by storing information in a variety of formats, or **representations**. In this chapter, we will review several different types of representations.

**Topics**

- Associative Networks
- Spreading Activation
- Semantic Networks
- Mental Models
- Scripts and Schemas
- External Cognition
- Explanatory Depth

# Work the Network: Associative Networks

## Learning by Doing

Associations are connections or relationships between two or more ideas. Let's explore that a little bit. Below is a list of words. What is the first word you think of when you read each item in the list?

- Car
- Computer
- Coffee
- Soda
- Hamburger
- Perfume
- Shoes
- Grocery Store

What was the first word you thought of when you read the word *coffee*? If the first image or word that came to your mind was *pot* (i.e., coffeepot), then you have a mental representation where those two concepts are tightly intertwined.

If you were tempted to respond with the name brand for any of these objects (e.g., *Starbucks* coffee), then that's a sign that their marketing department has done an excellent job creating a strong association between the goods they produce and their company's name.

## Contradictions in Memory

Our intuition about how memory works says that you can only remember a couple of things at a time, right? For example, if I start rattling off a grocery list, you might want to start jotting things down after I list the fourth fruit or vegetable.

So, here's the conundrum: why does memory get better when we start *adding* additional information? That sounds like a contradiction, right? Absolutely! But there's a good reason why it works, and it has everything to do with the way memory is structured.

Our memory system is a fascinating knot of complementary (and often contradictory!) mechanisms. We need these different systems because

our environment is sufficiently complex. We are confronted with many different tasks that include different sources of information. If you have a quick task that will only take a few seconds, then you need a fast memory system that inhales information and spits it out quickly. However, most of the interesting things that we do require us to remember something over a long period of time. You might call that "learning."

How, then, can we enhance our learning? How can we make sure the information that we see or hear gets cemented in long-term memory? One memory hack is to start adding all sorts of details that will help enhance the memory that you want to form. Here's an example from my own life.

## What's in a name?

A few weeks ago, I met one of my new coworkers. I had no problem remembering her first name, but her last name escaped me. It's embarrassing when you can't remember someone's name, even when you try. I needed help, and here's what I came up with.

I am a hockey fan, and in college I started following the Detroit Red Wings. They have a history of recruiting promising players from other countries. While these players might not shine during their first year, the Red Wings sign them for extended contracts and commit to developing their talent. A perfect example is when the Red Wings signed Pavel Datsyuk in 2001.

So, what does a forward for the Red Wings have to do with remembering my coworker's name? Well, the first five letters of her last name are "Pavel" (plus some additional letters at the end). In effect, what I did was add a bunch of seemingly irrelevant information to help me remember her last name. I made an effort to embed her name in a larger network of information. Moreover, when I try to recall her name, I have several hooks to get me to the right name. I can think about the field of cognitive science, hockey, or work, and all routes should lead me to the desired destination.

Why does that work? Or said another way, what does the structure of long-term memory look like? I have no idea, mainly because it is so fluid and multifaceted. However, one way cognitive scientists have attempted to visualize the complexity of our memory is to use a node-link structure called an **associative network** [1]. A small portion of my network probably looks like Figure 2.

Each node is a concept, and a link between them is an "association." In other words, each concept reminds me of the other nodes connected to

it. For example, when I think of John, I am reminded of Chas (and vice versa). The degree to which concepts are connected also matters. The distance between hockey and cognitive science is remote; therefore, they shouldn't remind me of each other.

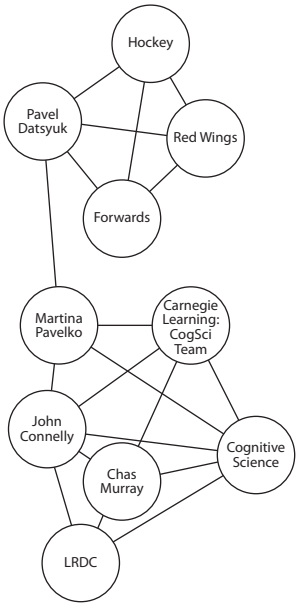


*Figure 2. My associative network for the people I work with.*

## The Classroom Connection

The concept of an associative network has obvious implications for education. For example, suppose you were teaching a biology class to a group of young children. They know the definition of a "mammal," and they can give many examples (e.g., *cats* and *dogs*) and counter examples (e.g., *birds* and *fish*). When they first learned about mammals, they learned that mammals have a couple of defining characteristics: they breathe air; they have fur or hair; they have three inner-ear bones; they give birth to live offspring; and they nurse their young. Most kids at this age, however, incorrectly classify a whale as a type of fish. That means they think whales don't have hair and don't give birth to live young (or nurse them for that matter!).

In essence, what you have to do as an educator is completely break one of the links in their associative network and moved it over. Thus, learning might look like Figure 3. An associative network representation helps to demonstrate the important role of prior knowledge in learning. It also

helps explain other cognitive phenomena like **priming**, **cued recall**, and **spreading activation** (all of which will be the topics of future sections).

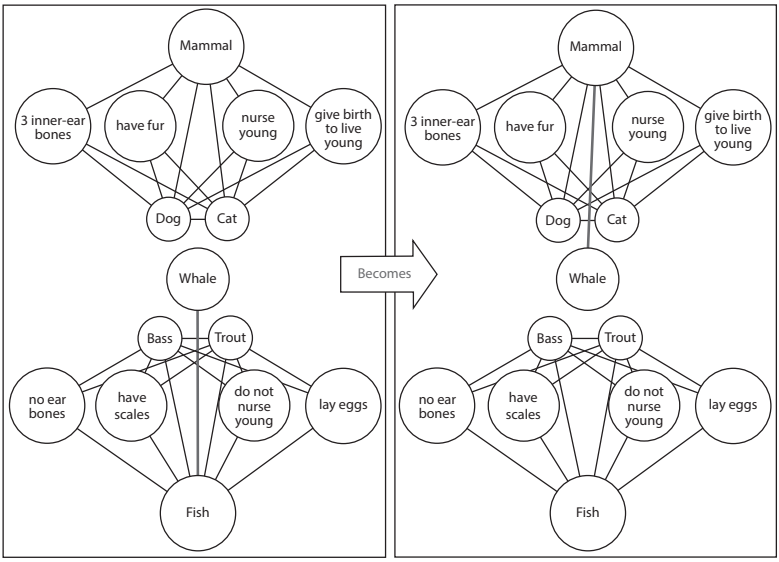


*Figure 3. An associative network of mammals and fish.*

## Going Beyond the Information Given

[1] My favorite empirically derived network can be found in the following paper. It depicts an expert child's representation of her dinosaur knowledge.

Chi, M. T. H., & Koeske, R. D. (1983). Network representation of a child's dinosaur knowledge. Developmental Psychology, 19(1), 29–39.