STUDENTS

Enhancing Concept Comprehension and Retention

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The traditional picture of the brain as a recording machine has long been discarded and replaced by a partial, yet more coherent theory of cognition. The brain does not merely record information — it categorizes it, reducing the complexity of conceptual structures by breaking them into meaningful chunks which it can more quickly and accurately recall. This "cognitive compression" allows the brain to reduce complicated information to a manageable scale. We've known this about the brain for a while now, but the implications of these insights into learning are just beginning to be felt in how we approach our teaching. Knowing how the brain works suggests several important principles we need to keep in mind in order to enhance concept comprehension and retention in our students.

Short Cuts of the Mind and Where They Go Wrong

The principle of **cognitive economy** underlies all of our higher cognitive activities — memory, perception, knowledge organization, and problem solving. Categorization devices, such as compression, help generate knowledge structures (schemas, frames, scripts) to avoid overloading our cognitive functioning. For example, humans can recognize at least 7.5 million different colors of reflected light and an estimated 10 million colors of emitted light. We cannot, however, remember names for each hue, or even most of them. Instead of using up processing and memory space for this task, we use a few categories to cover many different hues. Those of us who don't need much color differentiation as a part of our life's work may use only about 20 or fewer color names to refer to all of them.

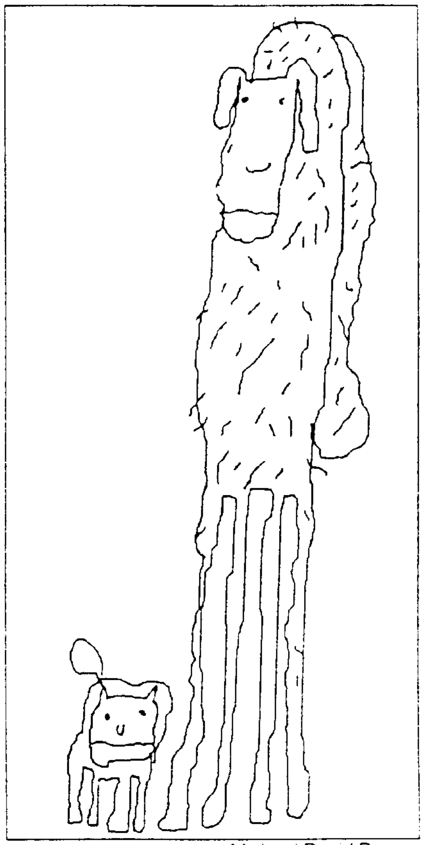
Categorization determines how a new concept is encoded. The encoding process plays a crucial role in both the concept's **acquisition**, or incorporation into existing knowledge structures, and in its **recognition**, or retrieval from long term memory. Cognitive economy also plays a role in **production**, putting the new concept to work in abstraction, generation, and inferences. Knowing about some of the devices our minds use to acquire and retrieve concepts and to make interpretations and inferences is essential for helping our students learn better. Also, we benefit from knowing how "cognitive economy" sometimes shortchanges us, as when we exaggerate the degree of commonality between objects and events, overestimate our influence on the future, encode into the wrong category, or draw fallacious inferences. Such knowledge can help us help students avoid some common mental mistakes.

Here are some general cognitive processes and principles that promote rapid and efficient encoding, retrieval, and production of concepts together with some positive implications for our teaching. The first principle, **prototypicality**, tells us that we tend to classify new concepts according to their similarity to "core" properties of existing concepts. We then apply relatively simple resemblance criteria to an object to determine if it is a member of the category. For instance, if something resembles a barking entity with four legs and a tail, it is quickly classified as a dog.

Do: Think of major examples.

Choose examples with all of the desired properties of the concept, stereotypical or classical examples. Also, avoid teaching about exceptions or outlying examples early on. That is, when teaching someone what a dog is, do not show a Chihuahua or a Great Dane. Choose an average, mutt-like example.

The next principle, **availability**, teaches that we tend to reason with information readily available, and make judgments (for instance, about properties of certain concepts) by the ease with which instances come to mind. For example, most people believe that their chance of dying in a tornado is greater than the likelihood of dying from asthma. Actually people are twenty times more likely to die from asthma. Tornados get attention; asthma



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doesn't. As a result people overestimate their chances of dying from one rather than the other. Two subprinciples help explain this cognitive inclination and how to use it to teach more effectively:

The first, **vividness**, says we tend to assign larger weight to concrete, vivid information that exhibits space or time proximity, or has emotional impact or implies a moral judgment. Vivid "concrete" information, such as "the Indiana University Credit Union was robbed by an IU graduate student armed with an AK47 assault rifle" dwarfs pallid reports of important facts such as "many banks are robbed each year," and is more likely to be stored and remembered because of its impact.

The second, **anchoring**, tells us the information we initially encounter affects our interpretation of subsequent information so strongly that we sometimes resist accepting additional and more relevant information. For example, when asked to choose the word that does not belong in the sequence SKYSCRAPER, CATHEDRAL, TEMPLE, PRAYER, people tend to choose PRAYER. But, for the sequence PRAYER, CATHEDRAL, TEMPLE, SKYSCRAPER, people tend to pick SKYSCRAPER. The obvious reason is the anchoring effect, generated by the first word in the sequence, on the encoding categorization of the task.

Do: Use memorable examples, vivid and concrete. Anchor them carefully.

A tendency that may result from cognitive economy is **overconfidence** in understanding, memories, and judgments. People are insufficiently critical of their inferential processes. Unaware of the reconstructive nature of their memories, they tend to regard their perception as a copy machine and their memories as photocopies of experience. Overconfidence implies not only inaccurate retrieval and inference, but also failure to recognize the need to improve. There are ample examples of overconfidence. Although statistics indicate fastening one's seatbelt significantly decreases one's chances of dying in a traffic accident, only 60% of the driving public buckle up on a regular basis. The rest believe what happens to others won't happen to them, that what's true for others isn't true in their case. They'll remember, they'll be sharp; they don't need to think ahead, review or plan.

Another way our brains reduce the immense amount of incoming information and efficiently use our coding and computational space is through **conservation**. One of the brain's tasks is to extract the constant, invariable features from the perpetually changing flood of information it receives. We do not consider all of the details in any information we file away in our minds, nor in retrieving or using it. We use heuristics to efficiently make these choices. But when a misjudgment is made in the transformation, a number of mistakes or biases may occur. One bias is attending to the surface appearance of a task or concept rather than to its formal structure. This may be why students find exam questions that use a concept in a new context or with a new example so difficult.

The bias of **belief perseverance** can be attributed to the "side effects" of conservation. We tend to be reluctant about reexamining our beliefs, even when the major evidence for their acquisition has been totally discredited. Worse, people tend to hold on to a belief, even when its credibility has been completely destroyed. Because of this belief perseverance, we often treat disconfirming information with deliberate misinterpretation as confirming evidence, or assign low weight to it or ignore it completely. The most famous experiment displaying this phenomenon (Ross, Lepper, and Hubbard, 1975) asked three groups of people to discern authentic suicide notes from inauthentic ones. When asked to evaluate their performance in a postexperimental questionnaire and to rate their ability in suicide-note discrimination cases, the subjects who had been given highly positive feedback reported evaluations far higher than the others, and the opposite evaluation was self assigned by the "failing" subjects. However — and especially important in its implications for teaching — when warned in advance of the biases they might fall into, more than half of the subjects were able to avoid them.

Do: Point out common errors that learners in your course tend to make.

Make note of their most frequent mistakes. For example, an Economics professor says his students are often surprised by the gap between what they think they know and how difficult they find the problems on the first exam. He tells his students, "Be aware that a common mistake in this course is to memorize your notes and text as your sole study strategy. You must practice solving many problems to do well on the exam."

How to Teach a Concept

Knowing how the short cuts that the brain uses to increase efficiency work can inform what we do when we teach a new concept. Based on cognitive principles, we believe a new concept is best introduced in four successive stages.

Stage 1: Introduce the concept in a vivid, familiar example; this helps tie the new concept to old knowledge. In class, describe something students are familiar with, something that college students would have on their minds, or tell a story with lots of details, or show a video to provide them with a detailed example.

Stage 2: Introduce an unfamiliar context for the concept, one that is unlikely to be close to the students' everyday experience.

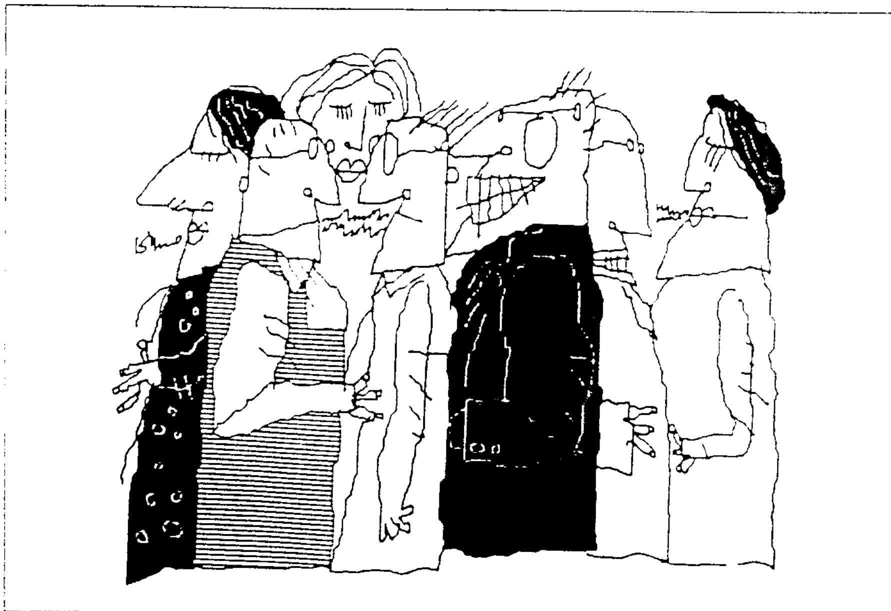
Stage 3: Once the concept has been presented in simple and in theoretical applications, a definition may enhance the comprehension by smoothing the edges of the informal representation and thereby provide a rule for correct production.

Stage 4: Students must practice thinking in terms of the new concept to really make it a part of their knowledge. Have them do something with the concept, such as teaching it to someone else, writing their own example of it, or summarizing it in their own words.

The first two steps encode the concept, while the final two, abstract definition and production, require reconstruction from the encoded concept. By going through these stages, we can reinforce the mind's own processes for storage and retrieval.

A Final "Do"

Since we know that our brains sometimes shortchange us when left alone to figure things out, a final "do" might be to encourage our students to form study groups with their peers. Study groups are a good way for students to learn new concepts. People can construct only a small number of scenarios and options in working memory at a time. Further, the construction of one picture normally diminishes our ability to generate alternatives. Thus, working with others on the same learning task reduces the risk of being "stuck" with the wrong knowledge structure, of being futilely anchored, and of working with the personally vivid formation rather than the appropriate one. As we've long suspected, brains often need other brains to do their best work.



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