How Students Learn

"As soon as you write an equation, it is wrong, because reducing a complex reality to an equation is just too simplistic a view of things. Large parallel computers, with large amounts of memory, may allow us to develop an entirely new sort of physics where . . . we can just store in the computer the facts. Then we can extrapolate and we can predict. That's what physics is about: extrapolating and predicting."

A. Tarantola[1]

Experts and Novices

To better understand the factors involved in learning, it is useful to take a look at people who seem to have learned the most. What are the fundamental differences between experts and novices? We know that novices do not become experts simply by virtue of length of service or even hard work, but why not? What do experts know or do differently?

- Experts consistently notice features and patterns of information that novices do not notice. In a study of chess players with varying levels of experience, chess masters saw moves and strategies that lesser players did not see.[2] Similarly, a study of teachers revealed that after observing videotaped classroom lessons, more experienced teachers had very different understandings of the events they were watching than did novice teachers.[3]
- Experts have a great deal of content knowledge that is organized in ways that reflect deep understanding of the subject. For example, physics experts organize their problem-solving ideas around major principles that are applicable to the problem, while beginners—even competent beginners—rely more on manipulating memorized equations.[4]
- Experts have not only acquired knowledge, they seem to have developed an efficient, mental "filing system." They don't have to search through everything they know to retrieve knowledge relevant to a particular task. The knowledge has been "conditionalized"—it includes a specification of the contexts in which it is useful.[5]
- Experts are able to retrieve important aspects of their knowledge with relatively little effort. This doesn't mean experts can do things faster than novices. In fact, because experts take the time to understand the problem fully, rather than hurry into assigning pat answers, they may take longer.[6] The amount of information a person can attend to at any one time is limited.[7] Ease of processing gives a person more capacity to attend to other tasks. For instance, novice readers are too focused on decoding words to devote attention to the task of understanding what they are reading.[8]
- Though experts know their disciplines thoroughly, there is no guarantee that they can teach it to others. Experts easily lose perspective of what is easy and what is hard. To teach well, an expert must not only have mastery or advanced knowledge in his or her discipline, he or she must also be an expert in teaching.[9]
- Experts have different levels of flexibility in their approach to new situations. Some expert chefs excel at following a fixed recipe, while others are able to improvise with equal or even better results.[10] Experts step back from their first impressions of a problem and question their own relevant knowledge.

- Not only do experts apply their expertise to solving problems, they also question whether the problem as presented is the best way to begin. The business world likes to call this “thinking outside the box.” Experts don’t simply try to do the same things efficiently, they try to do things better.

There is much to be learned from the expert learning model, but we cannot assume that by simply exposing students to the model, they will learn effectively. What students learn depends heavily on what they already know.

By the same token, not all teachers will become experts either. The ones who do, however, should be given the space and time to do what they do best. The ones who don’t should be given the same opportunity to do what they do better.

Adapted from J. D. Bransford, A. L. Brown, and R. R. Cocking, *How People Learn: Brain, Mind, Experience, and School,* National Academy Press, Washington, DC, 1999.

Endnotes

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