How novices differ from experts

Science of Learning
Best Practices for Teaching and Learning

Now, let's talk about how understanding the differences between novices and experts can have profound impact for our teaching.

Studies probing the differences between how novices and experts organize knowledge have revealed that experts' knowledge is not a list of facts and formulas. But rather, that their knowledge is organized around core concept or ideas. This results in a division of knowledge into interrelated chunks, which allows experts to select relevant knowledge from a vast knowledge repository easily and efficiently.

Let's use an example to demonstrate this finding. In this particular study, a chess master and a class A player-- which is a good player, but not a master-- and a novice player, were given five seconds to view a chess board positioned from the middle of an actual game. After five seconds, the board was covered, and the study participants were asked to recreate the board positions from memory.

This was repeated several times to allow participants to eventually get all the positions correctly. Plotted in this graph is a number of trials versus a number of pieces correctly recalled.

On the first trial, the master player correctly positioned more pieces than the class A player. 16 versus eight. And correspondingly, the class A player correctly placed more pieces than the novice player. Eight versus four.

However, these differences in performance only occurred when the board was arranged in a meaningful way. When chess pieces were randomly arranged on a chess board, then the number of pieces that were correctly placed on the board after one trial by the master, class A, and novice players, was the same. Approximately three pieces.

This example demonstrates that the process of making hierarchical mental models organized around core concepts or big ideas, allow experts to see patterns of meaningful information that novices cannot.

The other aspect of expert performance that is demonstrated in this chess example, is that experts have superior recall of knowledge, which surpasses working memory's limitation.

As we will explore in more detail in the session on preparing and presenting a lecture, there are limits to what people can hold in working memory.

By organizing information into meaningful chunks, experts are able to surpass the limits of working memory. This is known as chunking. Novices, on the other hand, lack hierarchical, meaningfully organized mental frameworks, and are therefore not able to take advantage of chunking.

Additionally, novice knowledge is compartmentalized and rigid, making retrieval, real understanding, and knowledge transfer very difficult. In contrast, expert knowledge is flexible and highly interconnected. They do not have to search through everything they know to find the relevant information for a particular problem.

A strategy for implementing these findings is to demonstrate how experts think and approach problems. This facilitates the evolution of expert thinking in our students. Keep in mind that students will still need to make sense of knowledge on their own, as we have previously mentioned. But making expert thinking transparent will facilitate the development of expert thinking over time.

As we have already discussed, experts are particularly good at retrieving information relevant to the task at hand. For knowledge to be easily retrievable, you should be conditionalized. That is, we should know under which circumstances the knowledge is useful and why.

Knowledge that lives in a vacuum is hard to retrieve. Traditional curriculum often fails to demonstrate to students the when and where and why's of using specific knowledge. Therefore, one of the recommendations for this strategy is to provide students with examples of when specific concept formulas, laws, et cetera, should be used and why.

Another recommendation for facilitating expert thinking is to make relationships of an idea or concepts explicit. This applies to both instruction and evaluation approaches.

For example, structure and organize your curriculum so that the connections between the concepts is clearly described. Refer to prior lectures and show how knowledge covered in prior lecture connects with current knowledge.

Ask students to build a concept map. Concept maps are diagrams that illustrate how concepts relate to one another. When building concept maps, students identify the concepts learned and organize them into hierarchical schemes.

In this example, a concept map is used to explain the seasons. Concept map variables used to explain why we have seasons are placed inside boxes, and are organized in a hierarchical manner, with the most inclusive and general of the variables at the top of the map, and the most specific, less inclusive variables below.

Another important characteristic of concept maps is that the relationships between the different variables are indicated with arrows. And the nature of these relationships is shown with labels. Notice that some variables can be connected to more than one other variable. This cross linking demonstrates rich interconnections that characterize deep understanding.

Concept maps are extremely effective tools for learning, because they provide opportunities for students to build and revise mental frameworks, and model the process of building mental models that experts develop through years of experience and practice.

Another strategy is to model how an expert approaches and solves a problem. Studies in physics, mathematics, history, among other disciplines, have demonstrated that experts approach problems carefully. First, thinking about the particular concept or idea that is involved in the problem.

In contrast, novices try to use surface features about the problem, such as the language and type of variables defined to search for the correct formula or analysis to apply. This results in an inability to apply knowledge to unknown situations.

Let's explore the following example that demonstrates how experts and novices differ in their approaches to problem solving. In this study, novices and experts were asked to group physics problems based on solution types. Novices tended to categorize problems based on similar surface features.

For example, the two different problems shown here were placed on the same category by novices because both have blocks on inclined planes. On the other hand, experts tended to categorize problems based on the major concept that can be applied to solve the problem.

In the example shown here, experts justified the categorization of two seemingly different problems, because they both demonstrate the concept of energy conservation.

Therefore, when solving problems in front of students, take time before you begin to state and explain your approach. Reveal to your students the sequence and nature of thought processes that take place in your mind when solving problems. In addition, when you ask students to solve problems, also ask them to justify their particular approach.