**Principle 1**: **Experts solve problems by identifying deep structures.**

**Example 1:** Some time ago, my friend who likes to work on cars told me that when a car fails to start the problem fall into two categories: “spark” or “gas.” Either something is preventing the spark plugs from igniting the gasoline, or something is preventing the gasoline from being injected into the cylinder. To me, this represents one way experts identify what I, as a novice, see as a single problem as one of a class of problems. I can imagine that identifying one or another initial “root cause” would lead to different lines of investigation for possible problems. Yet, to me the car just won’t start.

**Example 2:** In my job, I sometimes work with students who are making video productions as assignments in the classes they are in. Students can sometimes identify that their video is unsatisfactory, but are unable to tell specifically what is wrong. In many cases the problem with the video is related to pacing. Pacing is the ease of progression of the film from one event to another with ease. It is related to many subtle aspects of the video production including: how long individual elements remain on the screen, the synchronization of the cuts with the soundtrack, and variation across the visual and audio elements. Students will often edit their videos with simple rules in mind. For example, often students attempt to make many short cuts using a rule of keeping no shot on the screen for more than three seconds. This simplistic rule ignores the relative importance of a given piece of video or audio in relation to the overall purpose of the production. A more expert approach to editing will factor in technical, aesthetic, and content considerations. As a relative expert in this field I am able to identify the deep structure of a problem and take steps to make the necessary corrections.

**Reflection:** For instruction, the activity of creating concept maps in class and sharing them with each other could help novices reveal deep structures. Also this technique can allow novices to gain perspective into the deep structures of experts, helping them to learn new ways to think about course concepts.

**Principle 2: Experts solve ill-defined problems by using analogies and by dividing problems into sub-problems.**

**Example 1:** Recentlymy mother called me for assistance with problems with her computer. It is often difficult for me to troubleshoot my mother’s computer over the phone for a number of reasons. Due to the ill-defined nature of her description of the computer problems, such as “the computer is running slowly,” I am not always sure of the specific steps to take to solve the problem. Rather, I work for more general heuristics, seeking to identify what type of problem she is experiencing. Is the computer slow in starting up? Is it slow once it is on the network? Is it only slow using Internet Explorer? Has she installed a resource-intensive software program that will inevitably run slowly on her laptop? Once the specific context and definition of slowness has been achieved I can then begin to explore the possible root causes of the problem. For example, if the computer is running slowly only when connected to the network is there an issue with the network card, the software driver for the network card, her router, or her Internet Service Provider? Exploring each theory leads to possible sub-problems.

**Example 2:** In the past, I worked with faculty to incorporate technology into instruction. In one case I worked with an instructor developing an assignment that incorporated analogies. In this assignment, Fire Science students were required to come up with an analogy for particular types of sprinkler systems. Students were presented with 4 types of sprinkler systems and were required to think of an analogy for one of the sprinkler systems and share it with the class. In assessing the students’ understanding, instead of having the students repeat back the components of the sprinkler system, they were required to understand the functionality by comparing it to something else. Also, by sharing analogies students developed more complex understandings of how the sprinkler systems function.

**Reflection:** In instruction, the effects of functional fixedness are a concern. When instructional approaches do not vary, students become used to solving problems in routine ways, making it less possible for them to see alternative solutions. In addition, students struggle with ill defined problems and need instructional design approaches that support this approach.