Creating and Using Guided Discovery Problems, Ann Bykerk-Kauffman

Why Teach with Guided-Discovery Problems?

Deep conceptual learning must be actively constructed by the learner. The learner must fit any new concept into his/her pre-existing framework of knowledge, reconstructing the logic steps that lead to and make sense of the new concept. Some students (like many of us academic-types) may naturally do this in the context of a lecture, but most cannot or will not because the task just seems too daunting or, frankly, boring. So for most students, the active construction of knowledge must be facilitated overtly by the instructor. One effective way to do this is through the use of guided-discovery problems. As a bonus, guided-discovery problems can make learning fun by taking advantage of the brain's natural attraction toward progressive tasks, each with just the right degree of challenge (witness the tremendous popularity of computer games with their multiple levels of difficulty). Finally, guided-discovery problems are especially effective at challenging and overcoming a major block to learning: students' misconceptions and naive preconceptions.

Some of these misconceptions and naive preconceptions are amazingly common. Thus you can specifically address them in guided-discovery problems. Here is a list of some especially common misconceptions and naive preconceptions —gleaned from my 16 years of teaching.

Examples of Common Misconceptions and Naive Preconceptions
The mantle consists of magma.
Tectonic plates = crust.
Convection requires the input of heat.
The cause of plate motion: tectonic plates are transported by horizontal currents in the mantle, like rafts floating down a river.
Plate boundary locations are fixed over time.
During an earthquake, the entire plate moves rapidly, as a rigid block.
Volcanic gases come from the atmosphere.
Crystallization requires drying.
Metamorphism requires melting.
As sediment settles to form a layer, the smallest particles settle on the bottom of layer and the largest settle on top (that's what happens when you shake a bag of potato chips, right?).
The moon's phases are caused by Earth's shadow.
The seasons of the year are caused by variations in Earth's distance to the sun.
The equator is warmer than the poles because it's closer to the sun.
Lower density materials contain more "air" than do higher-density materials.
Heat energy rises independent of the material it's in.
Materials that rise buoyantly through other materials do so because they are "stronger."
Materials expand when they cool (analogy: water expands when it turns to ice).
Global warming is caused by the hole in the ozone layer.

Suggestions for designing guided-discovery problems

Create a scenario for the problem that is relevant to real life. For example, in my Missing Half Dinosaur problem, the students imagine themselves as being in charge of a dinosaur dig and must correctly interpret a fault in order to locate the missing half of the skeleton.

Trigger students' curiosity by making the problem puzzle-like, a mystery to be solved.

As possible, include one or more hands-on activities. Analogous models are especially powerful but use them with care—they should really actually show what you want them to show.

When incorporating hands-on activities, keep procedures simple and provide clear instructions. The focus should be on understanding what happens, not on doing the experiment "right."

Structure the problem carefully so that it is be challenging but not too frustrating or anxiety-provoking. Edit out unnecessary frustrations such as typos or convoluted wording.

Keep busy work, such as repetitive calculations, to a minimum.

Write questions for students to answer that guide them through the process of knowledge construction.

Guidelines for writing effective questions

Don't assume a full understanding of underlying concepts supposedly learned in prior classes. Ask probing questions to make sure they have a clear full understanding of underlying concepts before building on them. Misconceptions are hard to shed—it may take several confrontations over several courses for students to completely shed them.

Build an understanding of each underlying concept individually before putting all the concepts together into a comprehensive model. For example in my lab on convection, students come to grasp the concepts of buoyancy, density and thermal expansion/contraction before combining them into the concept of convection.

For each concept, break the chain of logic into steps; ask only about one step at a time. This makes the problem less overwhelming. How do you eat an elephant? One bite at a time.

Ask questions that force students to confront specific misconceptions. For example, in my lab on the seasons of the year, students are confronted with the fact that, over the course of a year, Earth is closest to the sun in January.

Guidelines for facilitating guided-discovery problems

Have students work on these problems in (preferably assigned) groups. These kinds of problems can be very difficult to solve alone. By assigning groups, you smooth and hasten the process of initiating relationships, an especially difficult task for shy (though often bright and therefore helpful) students.

Do at least 3-4 of these problems during the semester and do the first one early on—that way the students can get used to them and won't find them so strange.

"Lecture" as little as possible before turning students loose on the problem. DON'T tell students any answers before they do the hands-on activities (i.e. if they know ahead of time what the "demonstration" is supposed to show, they will focus just on doing the procedure correctly, not on figuring out what's going on).

Clearly state the underlyinig question to be answered by solving the problem.

Brainstorming at the beginning of the session may be a good idea.

When students ask a question as they work on the problem, ask THEM questions that reveal how far they've gotten in their construction of the concept and exactly where they are stuck. Then give them just enough help (by asking leading questions, providing a piece of information or

explaining a concept) to get them unstuck. Once they're on the right track and making progress again, let them know that and then move on.