**Teaching problem-solving skills**

Many instructors in engineering, math and science have students solve “problems”. But are their students solving true problems or mere exercises? The former stresses critical thinking and decision­making skills whereas the latter requires only the application of previously learned procedures. True problem solving is the process of applying a method – not known in advance – to a problem that is subject to a specific set of conditions and that the problem solver has not seen before, in order to obtain a satisfactory solution.

Below you will find some basic principles for teaching problem solving and one model to implement in your classroom teaching.

**Principles for teaching problem solving**

* **Model a useful problem-solving method**. Problem solving can be difficult and sometimes tedious. Show students by your example how to be patient and persistent and how to follow a structured method, such as Woods’ model described here. Articulate your method as you use it so students see the connections.
* **Teach within a specific context**. Teach problem-solving skills in the context in which they will be used (e.g., mole fraction calculations in a chemistry course). Use real-life problems in explanations, examples, and exams. Do not teach problem solving as an independent, abstract skill.
* **Help students understand the problem**. In order to solve problems, students need to define the end goal. This step is crucial to successful learning of problem-solving skills. If you succeed at helping students answer the questions “what?” and “why?”, finding the answer to “how?” will be easier.
* **Take enough time**. When planning a lecture/tutorial, budget enough time for: understanding the problem and defining the goal, both individually and as a class; dealing with questions from you and your students; making, finding, and fixing mistakes; and solving entire problems in a single session.
* **Ask questions and make suggestions**. Ask students to predict “what would happen if …” or explain why something happened. This will help them to develop analytical and deductive thinking skills. Also, ask questions and make suggestions about strategies to encourage students to reflect on the problem-solving strategies that they use.
* **Link errors to misconceptions**. Use errors as evidence of misconceptions, not carelessness or random guessing. Make an effort to isolate the misconception and correct it, then teach students to do this by themselves. We can all learn from mistakes.

**Woods’ problem-solving model**

1. **Define the problem**
   * **The system**. Have students identify the system under study (e.g., a metal bridge subject to certain forces) by interpreting the information provided in the problem statement. Drawing a diagram is a great way to do this.
   * **Known(s) and concepts**. List what is known about the problem, and identify the knowledge needed to understand (and eventually) solve it.
   * **Unknown(s)**. Once you have a list of knowns, identifying the unknown(s) becomes simpler. One unknown is generally the answer to the problem, but there may be other unknowns. Be sure that students understand what they are expected to find.
   * **Units and symbols**. One key aspect in problem solving is teaching students how to select, interpret, and use units and symbols. Emphasize the use of units whenever applicable. Develop a habit of using appropriate units and symbols yourself at all times.
   * **Constraints**. All problems have some stated or implied constraints. Teach students to look for the words only, must, neglect, or assume to help identify the constraints.
   * **Criteria for success**. Help students to consider from the beginning what a logical type of answer would be. What characteristics will it possess? For example, a quantitative problem will require an answer in some form of numerical units (e.g., $/kg product, square cm, etc.) while an optimization problem requires an answer in the form of either a numerical maximum or minimum.
2. **Think about it** 
   * **“Let it simmer”.** Use this stage to ponder the problem. Ideally, students will develop a mental image of the problem at hand during this stage.
   * **Identify specific pieces of knowledge**. Students need to determine by themselves the required background knowledge from illustrations, examples and problems covered in the course.
   * **Collect information**. Encourage students to collect pertinent information such as conversion factors, constants, and tables needed to solve the problem.
3. **Plan a solution**
   * **Consider possible strategies**. Often, the type of solution will be determined by the type of problem. Some common problem-solving strategies are: compute; simplify; use an equation; make a model, diagram, table, or chart; or work backwards.
   * **Choose the best strategy**. Help students to choose the best strategy by reminding them again what they are required to find or calculate.
4. **Carry out the plan**
   * **Be patient**. Most problems are not solved quickly or on the first attempt. In other cases, executing the solution may be the easiest step.
   * **Be persistent**. If a plan does not work immediately, do not let students get discouraged. Encourage them to try a different strategy and keep trying.
5. **Look back**

Encourage students to reflect. Once a solution has been reached, students should ask themselves the following questions:

* + Does the answer make sense?
  + Does it fit with the criteria established in step 1?
  + Did I answer the question(s)?
  + What did I learn by doing this?
  + Could I have done the problem another way?

**Resources**

* Foshay, R., Kirkley, J. (1998). Principles for Teaching Problem Solving. <http://www.plato.com/pdf/04_principles.pdf>
* Hayes, J.R. (1989). The Complete Problem Solver. 2nd Edition. Hillsdale, NJ: Lawrence Erlbaum Associates.
* Woods, D.R., Wright, J.D., Hoffman, T.W., Swartman, R.K., Doig, I.D. (1975). Teaching Problem solving Skills.  
  Engineering Education. Vol 1, No. 1. p. 238. Washington, DC: The American Society for Engineering Education.

**Source:**

<https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/developing-assignments/cross-discipline-skills/teaching-problem-solving-skills>