While there is no "right" or "wrong" way to help students to solve problems, there are some approaches that tend to be more or less effective than others. Here we present an (incomplete) list of mistakes that are very easy to make as an instructor. Even the best of instructors can find themselves committing errors such as these, so revisit this list often to make sure you're doing all that you can to help them learn.

**SOLVING IT FOR THEM:** It is important to remember that your job is not to show the student how a particular problem should be solved, but rather help them discover for themselves an appropriate method for approaching the problem. This can sometimes be frustrating for both parties, as you will most likely know the answer from the beginning, and the student will often care only about obtaining such an answer. However, it is unlikely that deep learning will occur if the student does not make the mental connections for themselves.

**LETTING THE STUDENT CONSUME TOO MUCH TIME:** You may encounter students in your office hours that seem to refuse to leave. This can cause problems for other students who are waiting to be helped, and thus puts you in a rather difficult position. If you feel that you have given an appropriate amount of assistance, you may want to suggest to the student that they think about the problem some more alone, and to come back later if no progress has been made. Often they will be able to figure out the solution on their own, which in the end is probably better anyway, as it makes them less dependent on the hints of the instructor.

**GIVING DISCOURAGING FEEDBACK:** To a student that is genuinely trying hard to solve a problem, there is nothing more detrimental to their esteem than the discouragement of an instructor. Phrases such as "No, you're doing it all wrong" or "This is so simple, why can't you see it?" send a message that they are somehow deficient or incapable. Instead, try to convey that you understand their frustration, and are confident that they will discover the solution in due time.

**NOT CONSIDERING ALTERNATIVE APPROACHES:** You may find that after several attempts to lead the student in the right direction, they are still unable to see the light. When this happens, feel free to stop for a moment and reevaluate the approach you are taking as an instructor. Take your time doing this. You may realize that there is a simpler explanation than the one you have been trying to give.

**GIVING BAD ADVICE:** When you feel rushed and are under pressure to serve several students, it is easy to explain something either too rapidly or altogether incorrectly. Students tend to hang on every word of their instructor, especially when seeking help, so such mistakes can easily throw them off track. If you feel that you are going too fast or are giving inconsistent answers, slow down and take smaller steps. As you are explaining a procedure or process, check frequently that they are following you, and that you have not lost them completely.

**NOT LISTENING TO THE STUDENT FULLY:** It is common that people try to sense what the other is saying based on a few sentences at the beginning of the conversation, and cut them off midway. While it is important to gauge the reactions of the student, we must patiently listen to the students with an open mind until they finish what they are saying, and then respond thereon. Students try to get a boost to their self-esteem by stating the basics (like the problem data) initially before coming to the problem. That does not mean they know the subject thoroughly. Conversely, just because the student is very tense does not mean that they do not understand the basics at all.

**LEADING THE STUDENTS TO OBSCURE RESOURCES:** In an attempt help the students find answers on their own, you must make sure that the resources you lead them to are credible and easy to follow. If you falter on this aspect, students will either avoid you completely or try to get the answer from you directly, both of which are highly unadvisable.

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1 Prepared by Michael D. Moffitt (mmoffitt@umich.edu) and Shankara Kuppa (skuppa@umich.edu) on September 8th, 2005 for Engineering GSI Teacher Training.
# Teaching Problem Solving Skills

**Handout: Comparison of Novice and Expert Problem Solvers**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Novices</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memory</strong></td>
<td><em>Stores in small pieces</em></td>
<td><em>Stores in chunks or pattern</em></td>
</tr>
<tr>
<td></td>
<td><em>Files few items</em></td>
<td><em>Files ~50,000 items</em></td>
</tr>
<tr>
<td><strong>Attitude</strong></td>
<td>Tries once then gives up</td>
<td>Is persistent</td>
</tr>
<tr>
<td></td>
<td>Is anxious</td>
<td>Is confident</td>
</tr>
<tr>
<td><strong>Categorization</strong></td>
<td>Recalls superficial details</td>
<td>Recalls fundamentals</td>
</tr>
<tr>
<td><strong>Problem statement</strong></td>
<td>Has difficulty redescribing</td>
<td>Uses many techniques to redescribe</td>
</tr>
<tr>
<td></td>
<td>Is slow and inaccurate</td>
<td>Is fast and accurate</td>
</tr>
<tr>
<td></td>
<td>Jumps to conclusions</td>
<td>Takes time defining tentative problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May redefine several times</td>
</tr>
<tr>
<td><strong>Simple well-defined problems</strong></td>
<td>Is slow</td>
<td>Is fast (up to four times faster)</td>
</tr>
<tr>
<td></td>
<td>Works backward</td>
<td>Works forward with known procedures</td>
</tr>
<tr>
<td><strong>Strategy</strong></td>
<td>Uses trial and error approach</td>
<td>Uses a strategy</td>
</tr>
<tr>
<td><strong>Information</strong></td>
<td>Doesn’t know what is relevant</td>
<td>Recognizes relevant information</td>
</tr>
<tr>
<td></td>
<td>Cannot draw inferences from incomplete data</td>
<td>Can draw inferences</td>
</tr>
<tr>
<td><strong>Parts of harder problems</strong></td>
<td>Does NOT analyze into parts</td>
<td>Analyzes parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proceeds in steps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Looks for patterns</td>
</tr>
<tr>
<td><strong>First steps for harder problems</strong></td>
<td>Tries to calculate</td>
<td>Defines and draws</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Explores alternatives</td>
</tr>
<tr>
<td><strong>Sketching</strong></td>
<td>Often does not sketch</td>
<td>Uses considerable time to sketch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Presents abstract principles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shows motion</td>
</tr>
<tr>
<td><strong>Equations</strong></td>
<td>Memorizes or looks up detailed equations for each circumstance</td>
<td>Uses fundamental relations to derive needed result</td>
</tr>
<tr>
<td><strong>Solution procedures</strong></td>
<td>Uses “uncompiled” procedures</td>
<td>Uses “compiled” procedures</td>
</tr>
<tr>
<td></td>
<td>Decides how to solve after writing equation</td>
<td>Conceptualizes equation and solution method as single procedure</td>
</tr>
<tr>
<td><strong>Progress of solution</strong></td>
<td>Does not monitor progress</td>
<td>Keeps track of progress</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Checks off steps versus strategy</td>
</tr>
<tr>
<td><strong>Approach when stuck</strong></td>
<td>Guesses</td>
<td>Uses heuristics</td>
</tr>
<tr>
<td></td>
<td>Quits</td>
<td>Perseveres</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brainstorms</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>Is not concerned with accuracy</td>
<td>Is very accurate</td>
</tr>
<tr>
<td></td>
<td>Does NOT check</td>
<td>Checks and rechecks</td>
</tr>
<tr>
<td><strong>Evaluation of result</strong></td>
<td>Does not evaluate results</td>
<td>Evaluates based on broad experience</td>
</tr>
<tr>
<td><strong>Mistake or failure to solve problems</strong></td>
<td>Ignores mistakes</td>
<td>Learns from mistakes</td>
</tr>
<tr>
<td></td>
<td>Develops new problem solving methods</td>
<td></td>
</tr>
<tr>
<td><strong>Action</strong></td>
<td>Sits and thinks</td>
<td>Is very active</td>
</tr>
<tr>
<td></td>
<td>Is inactive</td>
<td>Writes questions or draws flow paths</td>
</tr>
<tr>
<td></td>
<td>Is quiet</td>
<td>Subvocalizes (talks to self)</td>
</tr>
<tr>
<td><strong>Decisions</strong></td>
<td>Does NOT understand process</td>
<td>Understands decision-making process</td>
</tr>
<tr>
<td></td>
<td>Has no clear criterion</td>
<td>Has clear criterion</td>
</tr>
</tbody>
</table>

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Teaching Problem Solving Skills

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Outline

- Problem Solving Tips
- Tailoring your Approach
- Common Mistakes
- Scenarios and Role Playing
  - Problem Solving round #1
  - Clarifying students’ thoughts
  - When you don’t know the answer!
- Tips for Facilitating Problem Solving
- Questions and Answers
Problem Solving Tips

1) Ask students to identify what they know or what is given. Help them to develop a method rather than providing them the answer.

2) Encourage brainstorming alternative approaches. Use different approaches yourself when necessary.

3) Acknowledge student’s ideas, be encouraging rather than dismissive.

4) Introduce the problem in an interesting way. Address the “why,” not just the “what”.
Problem Solving Tips

5) Maintain student involvement: make frequent eye contact, check for questions, use names. Listen to them fully.

6) Go step by step, using linking language. Slow down to avoid bad advice.

7) Relate the steps in the problem to other problems in the course material. Underscore differences and similarities.

8) Focus on key techniques, main logic and the significance of the problem. What do you want the students to learn?
## Knowing your Students

<table>
<thead>
<tr>
<th></th>
<th><strong>Novice Students</strong></th>
<th><strong>Experienced Students</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitude</strong></td>
<td>Quick to give up, frustrated &amp; anxious</td>
<td>Keeps an open mind, is persistent &amp; confident</td>
</tr>
<tr>
<td><strong>Problem Definition</strong></td>
<td>Has difficulty (re)stating the problem / model</td>
<td>Employs several techniques to (re)define problem / model</td>
</tr>
<tr>
<td><strong>General Approach</strong></td>
<td>Trial and Error</td>
<td>Tailored Strategy</td>
</tr>
<tr>
<td><strong>If Stuck…</strong></td>
<td>Guesses and/or jumps to conclusions, quits</td>
<td>Uses heuristics, brainstorms, perseveres</td>
</tr>
</tbody>
</table>
Tailoring your Approach

■ Where can problem solving be facilitated?
  ● Class: time-limited large group interaction
  ● Discussion: flexible large group interaction
  ● Lab: small group interaction
  ● Office Hours: individual interaction

■ How can problem solving approaches be tailored to the student? setting?

■ Minute Paper: Think of two or more ways in which you can tailor your problem solving approach to your specific setting and the range of expertise of your students
Your Chance to Try

- Pick a group of three.
  - GSI/IA: As the GSI/IA you should encourage the students to work out loud. Do not solve the problems for them.
  - Student: Try to solve the problem (not all are trivial). Ask questions, if you need follow up. If you know the solution, play along.
  - Observer: Write down comments about the interaction. What did the GSI do well and what could have been done differently?

- Determine the GSI/IA, the student, and the observer in your group.
- Each role will have a different handout. Please only look at the handout for your role.
Scenario 1:
Problem Solving

Keep in mind: Successful ways to facilitate problem solving
Scenario 1

- Determine the three letters that come next in this series:

  B A A C E E D I I E M M F __ __ __

- You have four minutes. Once you have completed the exercise, discuss and evaluate the problem solving approach employed in your group.
Reflection

■ As an observer, what did you notice? What did the GSI/IA actually do to help the student solve the problem? Did it work?

■ As a GSI/IA, how did you intend to help the student solve the problem?

■ As a student, was the GSI/IA successful in having you solve the problem? Why or why not?
Scenario 2: Thinking Aloud and Clarifying Thinking
Think Pair Share

- Think of two or more ways to encourage the problem solver to *think aloud*.

- Think of two or more phrases you could use to help students *clarify their thinking*. 
Problem Solving Approaches

- Encourage the problem solver to think out loud.

- Help students to clarify their thinking.
Scenario 2

What would the next line in this pyramid be?

1
11
21
1211
111221
312211

Switch roles. You have four minutes. Once you have completed the exercise, discuss and evaluate the problem solving approach employed in your group.
Reflection

■ As an observer, what approach did your GSI use? Did it work?

■ As a GSI/IA, how did you help the student clarify their thinking?

■ As a student, what phrases encouraged you to think out loud?
Scenario 3:
Unsure about the answer?
Open ended problems?
Approaches when you are unsure about the answer?

- Don’t provide incorrect information
- Don’t be pressured to answer at the moment
  - It’s ok to say “let me get back to you on this…” – Get back to them
  - It’s also ok to refer to the Professor to make sure
- Make a discussion with the student, get the student involved
- Provide alternative resources

Ensuring the integrity of your advice will give them confidence in you
Scenario 3

- What is the next symbol in this sequence?

- Switch roles. You have four minutes. Once you have completed the exercise, discuss and evaluate the problem solving approach employed in your group.
Reflection

- As a GSI/IA, how did it feel to be unsure about the answer?

- As an observer, what did your student or GSI struggle with?

- As a student, what did your GSI’s do to help you?

- How do you approach answering questions when there is not a sure answer?
Reflections on Problem Solving

- Refer to your minute paper.
- Would you change your approach after what you’ve experienced in the role plays?
- What strategies would apply to all settings? What wouldn’t work well in another setting?
- What strategies would you use for novice or expert students?
Conclusions

- Be aware of student attitudes, guide them towards useful problem-solving strategies.

- Ensure active listening.
  - Think/Pair/Share and other active learning methods.

- Maintain interest and enthusiasm.
  - Encourage the student

- Allow students to follow your train of thought.

- Relate approaches to relevant material.

- Summarize and emphasize.
Questions and Answers
Active Learning

- What active learning techniques were used in this session?
Teaching Problem Solving Skills

Handout: Wankat’s Problem Solving Strategy

The following is a sample strategy for solving problems. As you made the transition from novice to more expert problem solver by progressing from freshman year in college to graduate school, you have likely adopted a similar strategy. However, it is likely that you have not verbalized this strategy. When you act as a GSI, you should model a distinct strategy to students, and you should advocate that the students follow the approach. Even advanced students, those who can skip steps and those who resist such a formalized problem-solving approach, will eventually benefit from a disciplined approach to problem solving.

0. I can.
   • Motivation step – work on student’s self-confidence and remove anxiety as obstacle to problem solving.

1. Define.
   • List knowns and unknowns, draw figure – correct figures are critical.

2. Explore.
   • Think about it, or ponder – in a general sense. Is this a routine problem? What are alternative solution methods? What are some likely limits on the answer?

3. Plan.
   • Use formal logic to set up steps of the problem. Write appropriate equations for each step. Consider a flowchart for long problems. Solve without numbers. This step is difficult for “serial” thinkers as opposed to “global” thinkers.

4. Do it.
   • Put in values and calculate answer. Novices want to do this first. Better problem solving skills will result if the “Plan” and “Do it” stages are separated. Enforce this!

5. Check.
   • Check for calculation errors, but also compare with limits determined in the Explore step. Also compare answer to common sense.

   • Almost never done by novices unless they are explicitly told to do it. What has been learned about the content? Could the problem have been solved more efficiently? Was there a term that could possibly be neglected in general?
   • If problem was not solved correctly, what was done wrong? Students should get useful feedback and re-solve incorrect problems.

Note: More information is available in the GSI Guidebook on page 58 under the section “Teaching Students to Solve Problems.”

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