

Teaching Problem Solving

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- Individual consultations
- Seminars on teaching and learning
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- Teaching observations (recitations, classes, guest lectures)
- Resources on our website
 - ✓ <http://www.cmu.edu/teaching>
- Future Faculty Program

Future Faculty Program

- 10 seminars (including 6 core seminars)
- 2 teaching observations
- course design project
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Come talk to us at the Eberly Center!

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Objectives

By the end of this seminar you should be able to...

- articulate the issues raised by the expert blind spot
- identify different types of knowledge and understand the roles they play in problem solving
- describe several different strategies beneficial for teaching problem solving

Agenda

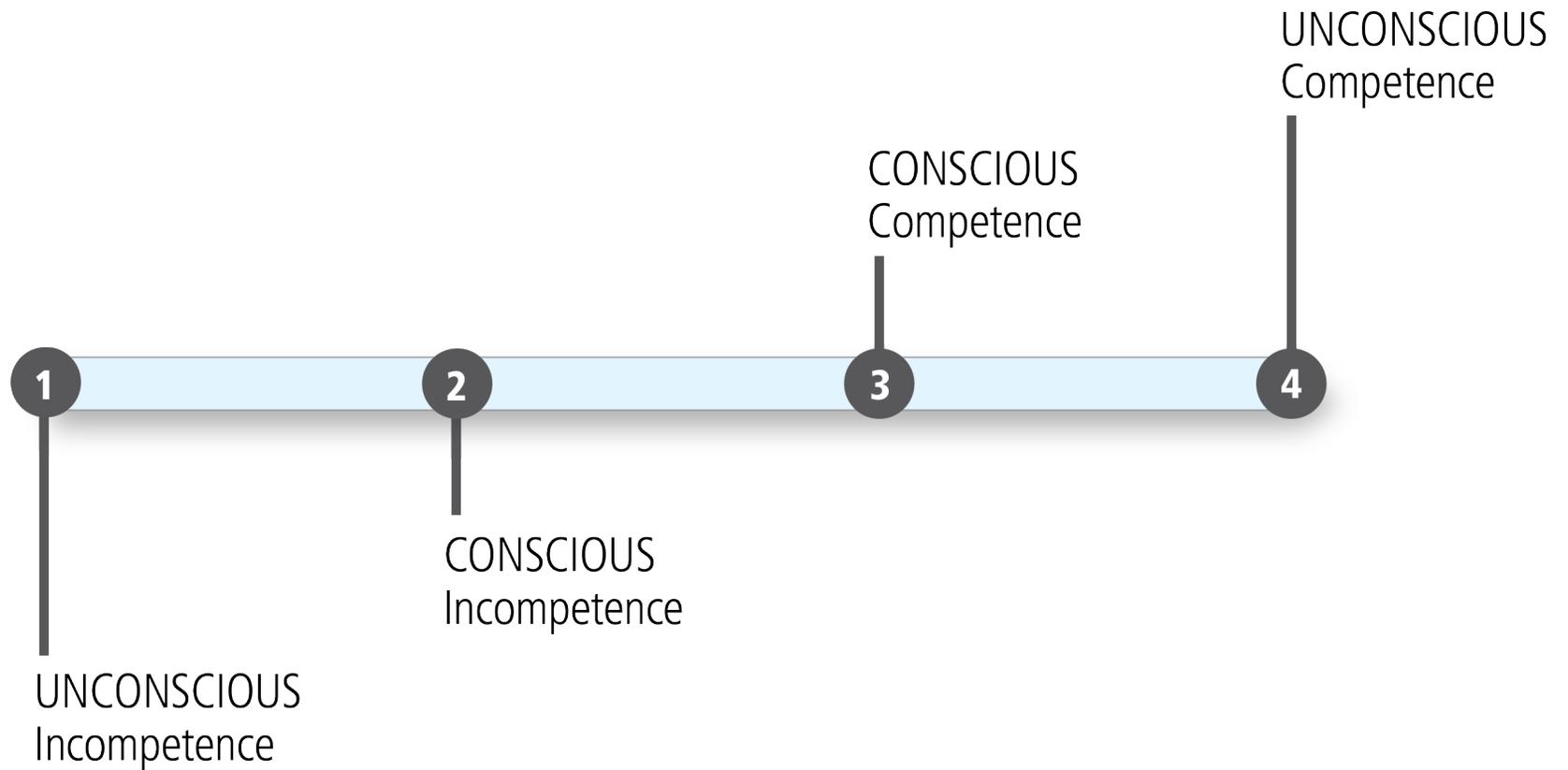
1. The Expert Blind Spot
2. Types of Knowledge
3. Teaching Strategies

What do you need to know to solve this problem?

A farmer wants to construct a rectangular enclosure for his sheep, using his barn as one side and building a fence for the remaining three sides. He has enough materials to construct 60 feet of fence (and his barn is a convenient 60 feet long). How long should he make each side in order to maximize the size of this enclosure?

The Expert Blind Spot

The development of expertise



Sprague & Stuart (2000)



Problems for Experts

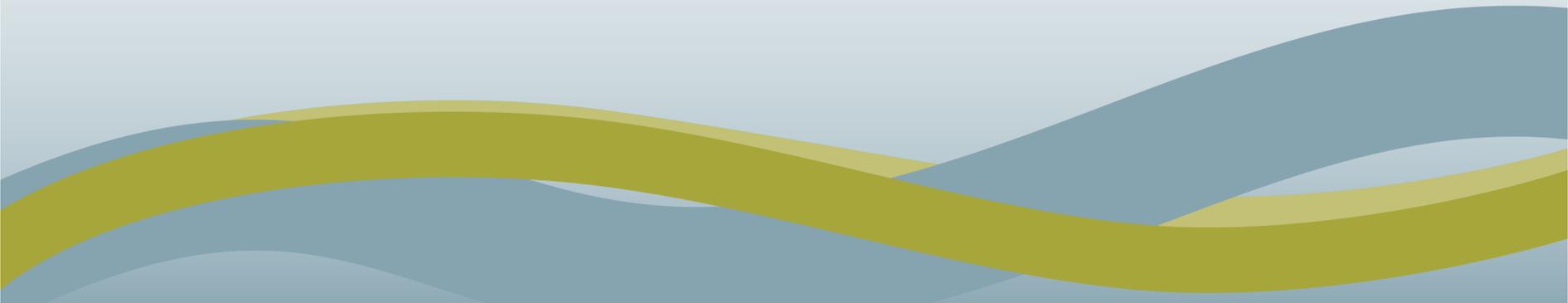
Experts often...

- over-estimate what novices know and can do
- under-estimate how long novices will take
- don't see the steps/pieces novices must learn
- mis-predict where novices will have difficulty
- presume that novices do things the way they do

What are some things you can do to guard against the expert blind spot?

cf. Hinds (1999); Nathan & Koedinger (2000); Nickerson (1999)

Types of Knowledge



Types of Knowledge

Knowing what	<i>facts, definitions, formulas, etc.</i>
Knowing why	<i>concepts, relationships, etc.</i>
Knowing how	<i>procedures, methods, steps, etc.</i>
Knowing when	<i>conditions of applicability, etc.</i>

Which types of knowledge get the most emphasis in undergrad math classes?

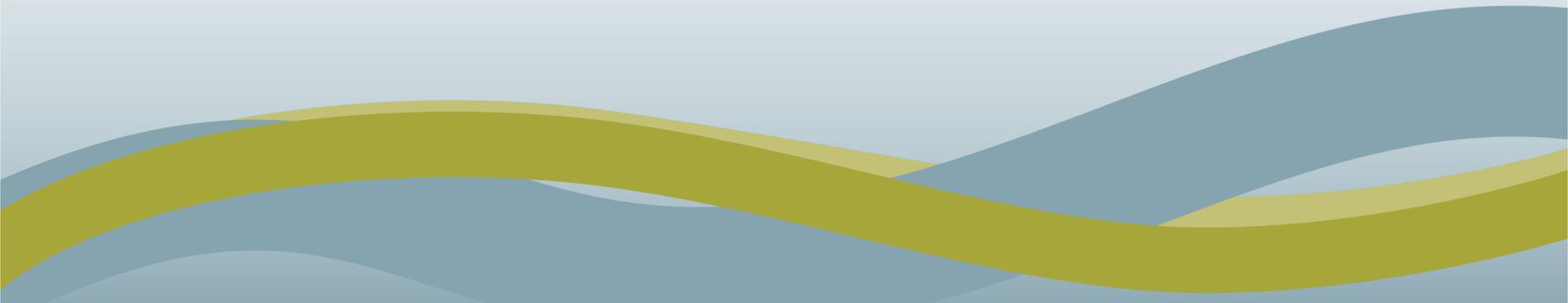
Reasons to Diversify

If we don't focus on all four types of knowledge then our students may be able to...

- apply a formula *but not explain the concept*
- state a theorem *but not know when/where to apply it*
- explain a procedure *but not perform it*
- find an answer *but not know what it means*

What are some things you can do in the classroom to help students gain all four types of knowledge?

Teaching Strategies



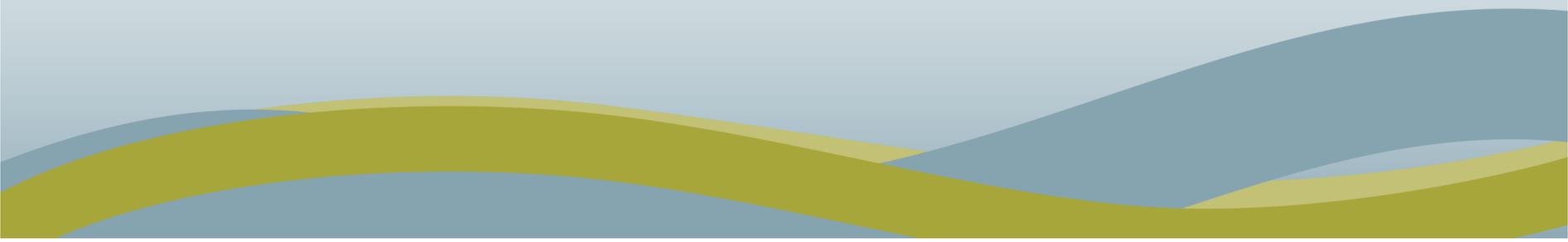
Video: Scalar Multiplication

As we watch this 2 minute video, consider:

What does the instructor say and do to help students fully understand scalar multiplication?

https://www.khanacademy.org/math/algebra/algebra-matrices/Basic_matrix_operations/v/scalar-multiplication

Some things for you to try:

1. Use *routine* and *non-routine* problems.
 2. Encourage *collaboration* and *group work*.
 3. Help students *reflect* on the problem-solving process.
- 

1. Use *Routine & Non-Routine Problems*

Routine Problems

- Can be solved using methods students are familiar with
- Often solved by replicating previously learned methods in a step-by-step fashion

GOAL OF ROUTINE PROBLEMS:

to help students understand the meaning of an operation or mathematical idea

1. Use *Routine & Non-Routine Problems*

Non-Routine Problems

- No predictable, well-rehearsed approach or pathway explicitly suggested by the task, task instructions, or a worked-out example
- Forces students to apply what they have learned in a new way

GOAL OF ROUTINE PROBLEMS:

to develop students' ability to think strategically

1. Use *Routine & Non-Routine Problems*

Non-Routine Problems

Non-Routine Problems force students to do things like:

1. interpret the problem
2. determine what information is relevant
3. determine how to use the relevant information
4. determine if information not presented in the problem is relevant (and how to find it)

All of these steps increase the **cognitive demand** on the student, and require **extra reasoning**.

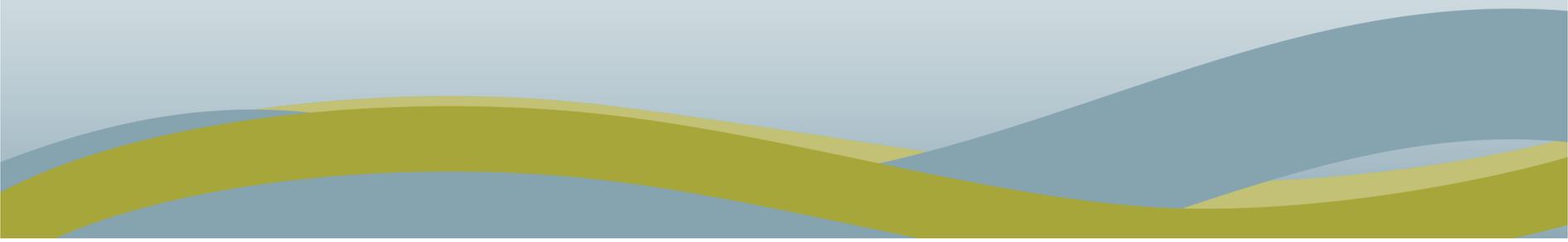
Non-routine problems help increase the **depth of student understanding**.

1. Use *Routine & Non-Routine Problems*

Aim to use both routine & non-routine problems for all problem-solving activities:

- for homework assignments
- during recitations & review sessions
- on exams & tests
- when you are introducing new material
- etcetera...

Some things for you to try:

1. Use *routine* and *non-routine* problems.
 2. Encourage *collaboration* and *group work*.
 3. Help students *reflect* on the problem-solving process.
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2. Encourage *collaboration and group work*.

Discussion Questions

What is the value of collaboration and/or group work for students in math classes?

What are some ways that you use (or could use) group work in a math class?

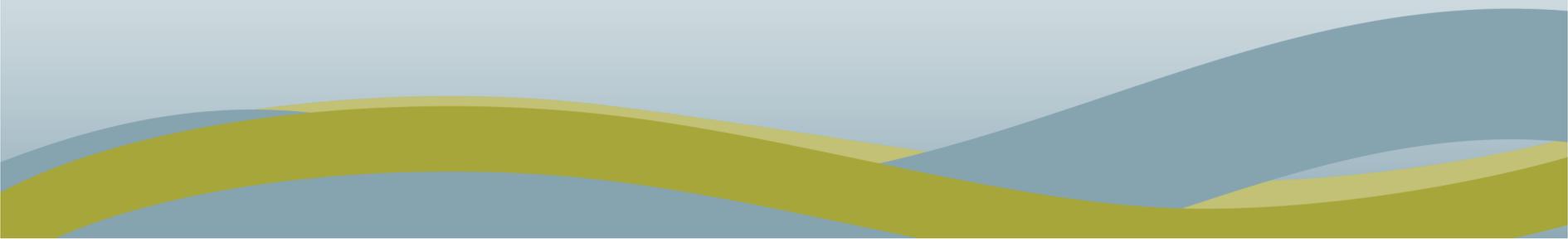
What are the down sides of collaboration and/or group work for students in math classes?

2. Encourage *collaboration and group work*.

Group Work & Collaboration: A Cornucopia of Benefits

- When students work together they each bring something to the table – and together have more resources at their disposal
 - When working together, weaker students learn from stronger students
 - When working together, stronger students have opportunities to articulate and explain their ideas – which solidifies their understanding and helps to expose errors in thinking.
 - Group work and collaboration reduce isolation.
 - As students talk about their work, they become more comfortable with the “language” they are learning.
 - Group work and collaboration help eliminate your expert blind spot.
 - Group work and collaboration help transfer ownership of the educational process into the hands of your students.
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Some things for you to try:

1. Use *routine* and *non-routine* problems.
 2. Encourage *collaboration* and *group work*.
 3. Help students *reflect* on the problem-solving process.
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3. Help students *reflect* on the problem-solving process.

What's the point of reflection?

Students learn math and solve problems better when they monitor their thinking and problem-solving steps as they solve problems.

- it helps them think about what they are doing and why
- it helps them make connections between old and new concepts
- it helps them identify distinct steps in a method
- it helps them identify problem areas and articulate questions

3. Help students *reflect* on the problem-solving process.

Discussion Question

What are some ways that you can help students monitor and reflect on the problem-solving process?

3. Help students *reflect* on the problem-solving process.

Helping Students Reflect:

- Give students a task list that identifies specific steps to solving problems
- Explicitly identify the steps in a solution, as you teach.
- Give students a list of reflection questions to answer as they solve a problem.
- Mention heuristics that you use when you are faced with similar problems.
- Model this behaviour when you introduce a problem-solving activity or a new concept.
- Talk through your reasoning, or ask your students to talk through theirs (“think-aloud”)

3. Help students *reflect* on the problem-solving process.

Sample Task List

- Identify the givens and goals of the problem.
- Identify the problem type.
- Recall similar problems to help solve the current problem.
- Use a visual to represent and solve the problem.
- Solve the problem.
- Check the solution.

How might you incorporate a task list like this into your teaching?

3. Help students *reflect* on the problem-solving process.

Sample Reflection Questions

- What is the problem asking?
- What do I know about the problem so far? What information is given to me? How can this help me?
- Which information in the problem is relevant?
- In what way is this problem similar to problems I have previously solved?
- What are the various ways I might approach the problem?
- Is my approach working? If I am stuck, is there another way I can think about solving this problem?
- Does the solution make sense? How can I verify the solution?
- Why did these steps work or not work?
- What would I do differently next time?

How might you incorporate reflection questions into
your teaching?

Summary

- Compared to your students you are an expert in your subject matter.
- There are different types of knowledge associated with problem solving.
- To effectively teach problem solving we need to diversify our approach:
 - ✓ Incorporate routine + non-routine problems
 - ✓ Encourage collaboration & group work
 - ✓ Help students monitor & reflect on what they are doing



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Thank you.