Assessing Efficiency & Innovation in Problem Solving

N. Sanjay Rebello

Elizabeth Gire

Kansas State University

Physics Education Research Group

Kansas State University

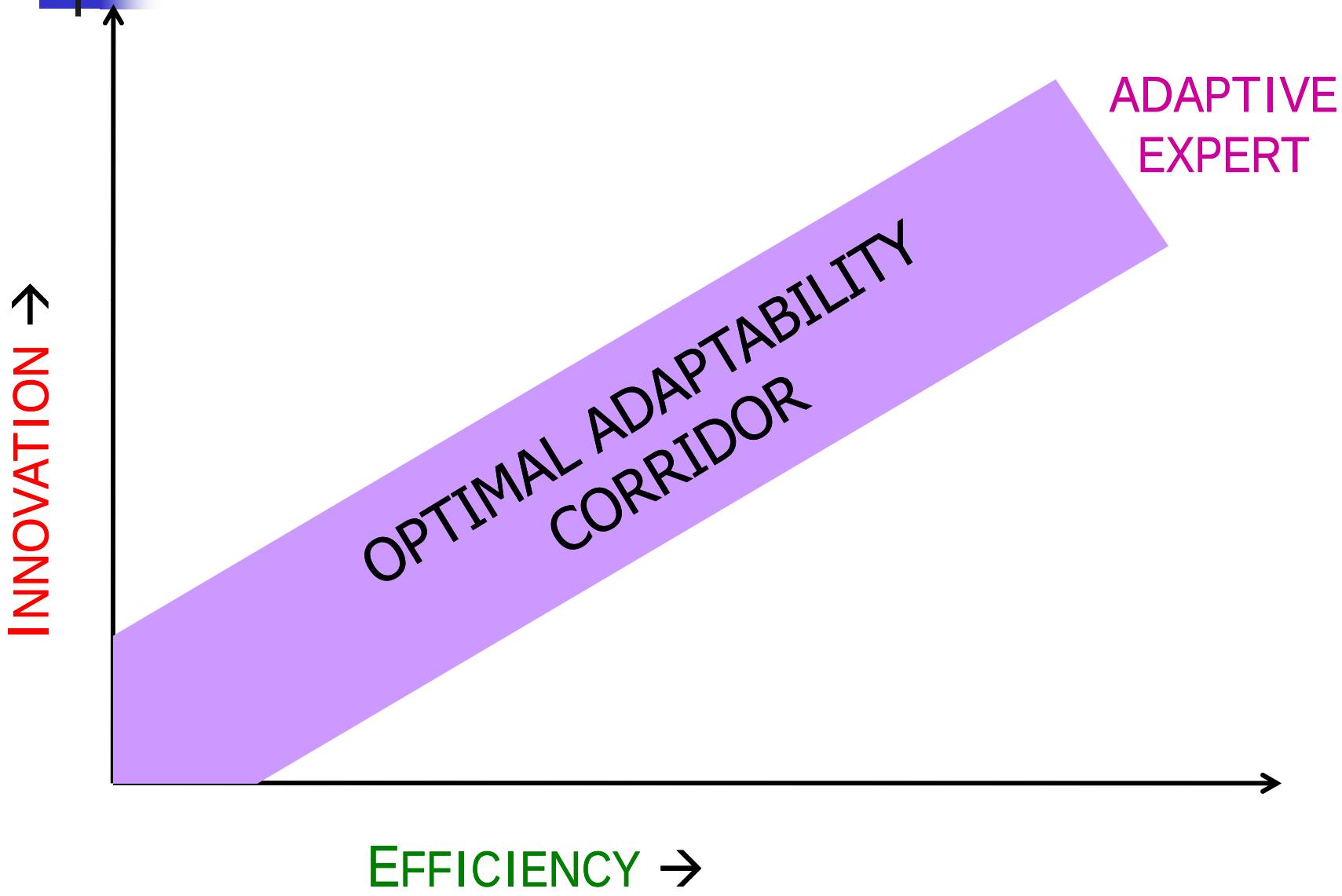
Supported in part by grants from the National Science Foundation

Efficiency & Innovation

Schwartz, Bransford & Sears (2005)

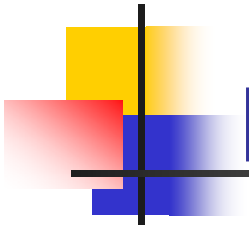
- **Efficiency**
  - Ability to “rapidly retrieve and accurately apply appropriate knowledge and skills to solve a problem”
  - “The best way to be efficient is to practice tasks and gain experiences with ... problems so that they become ‘routine’ and easy to solve later.”
- **Innovation**
  - “Often requires a movement away from what is momentarily most efficient for the individual.”
  - Abandon assumptions that “put people in a box, or more technically, constrained the problem spaces within which they work.”

Schwartz, Bransford & Sears (2005)



Goal

Explore the extent to which these ideas can inform our perspectives on physics problem solving.



Pilot Study

- What aspects of problem solving do these instructors associate with ‘efficiency’ and ‘innovation’?

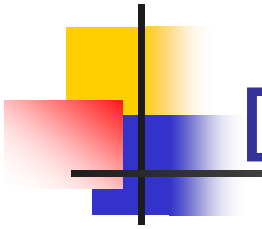
- What kinds of problems do these instructors create when testing for ‘efficiency’ and ‘innovation’?

Method

- Setting: Discussion group at weekly seminar attended by faculty and grad students.

- Participants:
  - 3 experienced faculty (Physics, Math, Chemistry) familiar with educational research.
  - 8 PER grad students & post-docs.

- Format:
  - Groups of 2-3 participants worked on discussion tasks.
  - Reconvened to share ideas with rest larger group.



Discussion Q1: **Efficiency**

What *elements* of a problem in introductory college math or science assess **efficiency**?

- Do have
  - "Time restrictions, " "Many problems in little time."
  - "Resource restrictions"
- Need to Know
  - "has seen problem before."
  - "memorized equations, definitions."
  - "If hint in the problem gives away difficult, innovative part."
- Asked to do
  - "rote algebra steps."
  - "Same calculation multiple times in problem/problem set."

Discussion Q2: **Innovation**

What *elements* of a problem in introductory college math or science assess **innovation**?

- What is New
  - "Crazy new context."
  - "New geometries," "All examples are x, new problem is y"
  - "Changing Representations."
  - "Setting up new equations."
  - "Changing initial conditions," or "thing you are solving for"
- Asked to do
  - "Look at work" done by others.
  - "Changing steps in the process."
  - "Combining several principles."
  - "Turning a problem we don't know into one that we know"

Discussion Q3: Problem Creation

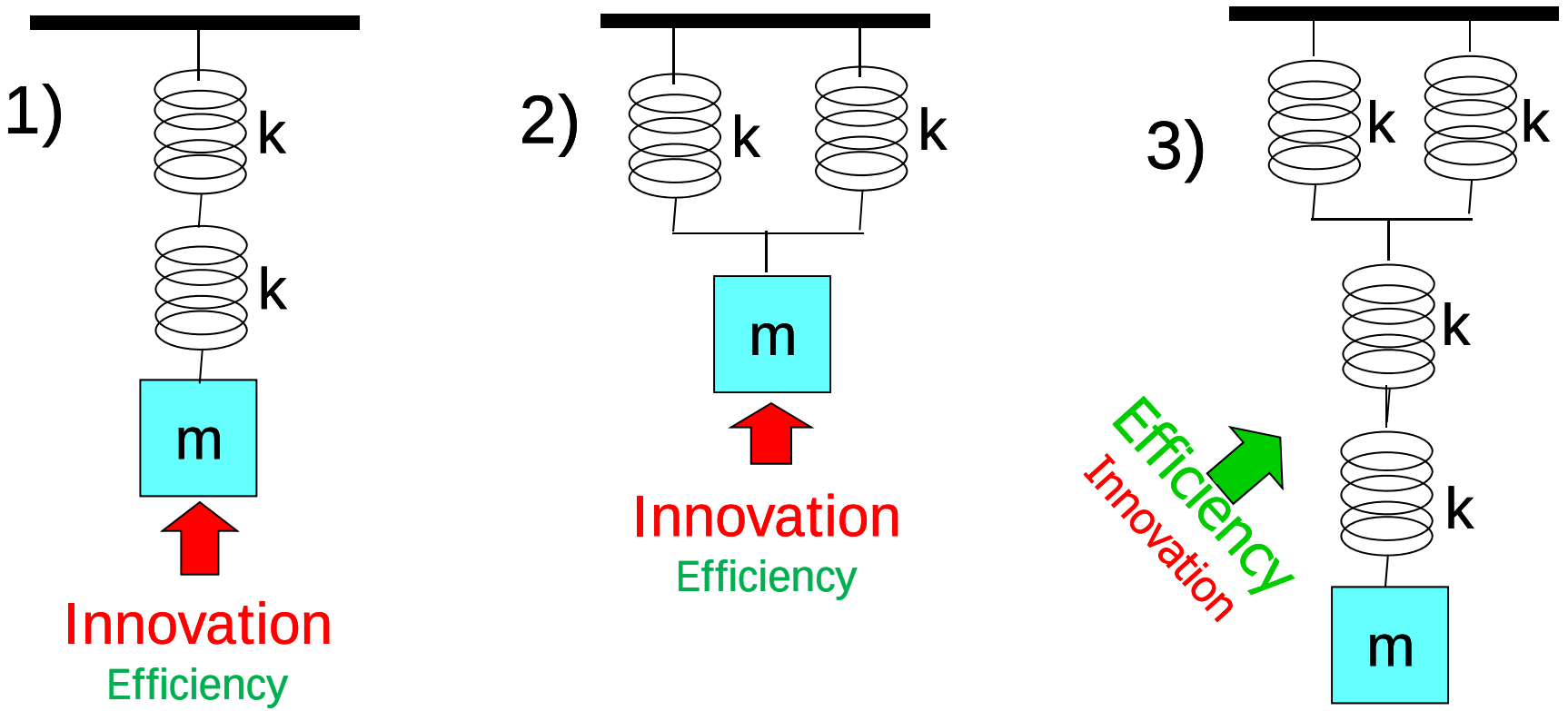
- Create a problem that may be typically asked in intro. physics (calc- or algebra-based)

- Identify elements in problem that contribute toward assessing
  - **Efficiency**
  - **Innovation**

Example Problem Created

Assumption: Students have already learned to find the frequency of *single* mass spring system

Problem: Find the frequency of the following mass-spring systems



Another Example Problem

Assumption: Students already know:

- Constant acceleration motion,
- Independence of x and y motion

Problem: A supply plane needs to drop its package at a specific target. If the plane is flying ‘h’ meters above the ground at ‘v’ mph, how far from the target should the plane drop its load?

Efficiency: Using 1-D equations & converting units.

Innovation: 1D + 1D = 2D.

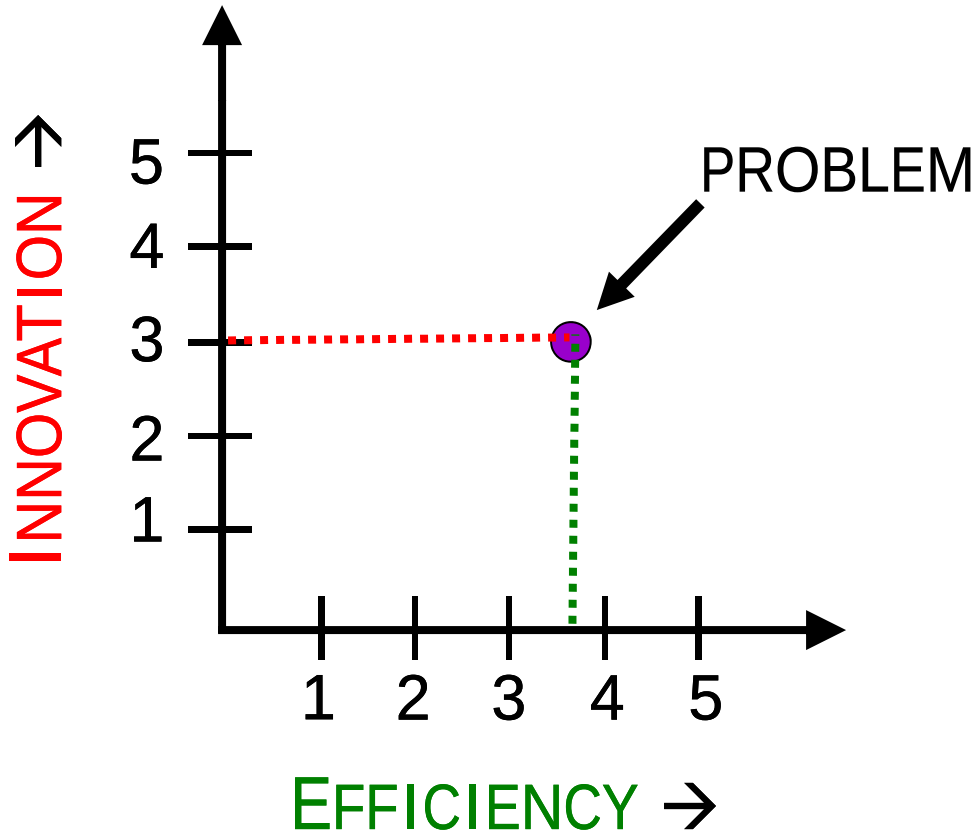
What we've learned so far

- Efficiency assessed by problem elements that
  - have time or resource restrictions,
  - demand well prepared prior knowledge
  - require familiar steps, repeated multiple times.
- Innovation assessed by problem elements that
  - present novel, unfamiliar situations.
  - demand combining different ideas, creating new ones
  - require recasting problem into one that is solvable.

Problems typically have elements that require both efficiency & innovation

What are our next steps

- Survey more instructors & students about views of efficiency & innovation in problem solving.
- Based on this input, develop a rubric to score problems on ‘efficiency’ & ‘innovation’ scales.
- Place problems in a 2-D ‘efficiency’ and ‘innovation’ space.



Implications

- Provide a lens to assess students' problem solving abilities across both dimensions 'efficiency' and 'innovation'.

- Help instructors design problem solving experiences that lie within the 'Optimal Adaptability Corridor'.

Thank You

For more information contact

Sanjay Rebello (srebello@phys.ksu.edu)

Elizabeth Gire (egire@phys.ksu.edu)