Assessing Efficiency & Innovation in Problem Solving

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Efficiency & Innovation

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)

ADAPTIVE EXPERT

INNOVATION

EFFICIENCY

OPTIMAL ADAPTABILITY CORRIDOR
Goal

Explore the extent to which these ideas can inform our perspectives on physics problem solving.
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
Assumption: Students have already learned to find the frequency of single mass spring system

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

1) \[ \begin{align*} &k \quad \text{I}n\text{novation} \quad \text{E}fficiency \\ &m \end{align*} \]

2) \[ \begin{align*} &k \quad \text{I}n\text{novation} \\ &m \quad \text{E}fficiency \\ &k \end{align*} \]

3) \[ \begin{align*} &k \quad \text{I}n\text{novation} \\ &m \end{align*} \]
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.
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

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