Instructors’ Views on what Students should Think About when Solving Physics Problems

Metacognition in Physics Problem-Solving – Instructors’ Views

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Outline

• What is Metacognition, & why do we care?
  • What are we doing?
  • What have we found?
    – Questions Raised
• Implications
What is **Metacognition?**

- **People’s Thinking about their own Thinking**


**Underlies all higher order thinking, especially problem solving!**
Why do we care?

• **Research has indicated** (Schoenfeld, 1983, 1985a, 1985b, 1987; Lester, Garofalo, & Kroll, 1989)
  
  – Expert problem solvers spend more time … **planning** the directions that may be taken … **monitor** and **evaluate** their actions and cognitive processes throughout problem-solving episodes than do less successful problem solvers

Since majority of our introductory students are largely unaware of their own thinking processes and do not (or cannot) do this, **instruction** is needed
What are we doing?

Learning of physics through problem solving

in this study …

Instructors’ beliefs and values about the teaching and learning of problem solving in physics

why instructors?

the task is …

to identify those beliefs and values


students

instructor

curriculum

Curriculum Implementation

??
What are we doing?

Problem Statement

Understanding the Problem

Looking Back

Carrying Out the Plan

Managerial Process

Making a Plan

Polya, Reif, Beichner, Heller & Heller, etc …

**What are we doing?**

- Problem Statement
- Understanding the Problem
- Planning Monitoring Evaluating
- Making a Plan
- Carrying Out the Plan
- Looking Back

**Disclaimer:** Instructors’ values, as inferred from what they talk about when describing the problem-solving process during the interview, are about valuing *metacognition* in students’ problem solving, not about how they actually solve problems or what they actually teach.

What are we doing?

As previously reported*, the study consists of:

- Interview tool based on instructional artifacts focused around a single problem
  - 3 Instructor Solutions
  - 5 Student Solutions
  - 4 Problem Types
- General & Specific Questions
- Sample of 30 physics instructors from 4 types of higher education institutions in the state of Minnesota
  - Research University (6)
  - State University (8)
  - Private College (9)
  - Community College (7)

Generate hypotheses to be tested with larger sample!

* AAPT Conference Presentations (Summer 2000 to Winter 2003);
What are we doing?

As previously reported*, the study consists of:

- **A targeted analysis:**
  - Identify parts of interview where statements about the problem-solving process were found in previous study
    - based on results from extensive analysis of interview with research university instructors
  - Code statements relevant to students’ problem-solving process into
    - Mechanical
    - Procedural
    - Metacognitive

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The first thing that students should do when solving a problem is visualize the situation

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What are we doing?

Separating metacognitive statements into

**Planning**
*Statements related to starting a solution to a problem*

**Monitoring**
*Statements related to checking the progress of solution*

**Evaluating**
*Statements related to checking the reasonableness of solution*
Here are some things that you might think

1. Instructors from different Institutions might value seeing metacognition in students’ problem-solving process differently

2. Instructors with different amounts of Teaching Experience might value seeing metacognition in students’ problem-solving process differently

3. When instructors value metacognition in students’ problem-solving, they value Planning, Monitoring, and Evaluating equally

Then again, you might think something else …
What have we found?

Contact Hours per Week vs. % of Metacognition/PS Statements

Range of % Meta/PS Statements from ~ 5% to ~ 50%
What have we found?

Contact Hours per Week vs. % of Metacognition/PS Statements

% Meta/PS: RU significantly higher than all others (p < 0.02)
What have we found?

Teaching Experience vs. % of Metacognition/PS Statements

Teaching Experience vs. % of Meta/PS Statements

Significant correlation $R = -0.51$ ($p < 0.01$)!
What have we found?

Teaching Experience vs. \% of Metacognition/PS Statements

Teaching Experience vs. \% of Meta/PS Statements

- \( R(\text{RU}) = -0.54 \)
- \( R(\text{SU}) = -0.29 \)
- \( R(\text{PC}) = -0.82 \)
- \( R(\text{CC}) = -0.86 \)
What have we found?

- Count of Planning, Monitoring, & Evaluating statements
  - Instructors stated significantly more statements about Planning than Monitoring or Evaluating
    - ~ 70% more Planning statements than Monitoring statements
    - more than twice as much Planning statements as Evaluating statements
Questions Raised

From this small sample

In students’ problem-solving processes:

1. Do RU instructors value metacognition more?

2. Do instructors with less contact with students and their work value metacognition more?

3. Do instructors with less teaching experience value metacognition more?

4. Do instructors value Planning more than Monitoring and Evaluating?
Speculations

From this small sample

• Offer a speculation to the questions on Contact (2) & Teaching Experience (3)

  ➢ Instructors repeatedly encountered students who cannot solve their problems
    ➢ See procedural & mechanical difficulties
    ➢ Try to change that by directly addressing those difficulties

  ➢ Not as apparent for instructors that teaching metacognitive processes addresses those difficulties
Implications

• Instruction is needed to help students develop their [metacognitive] processes while emphasizing the important role that these processes play in problem solving

• Original hypothesis: Instructors do not adopt curricular material due to a mismatch between their beliefs and values and the emphasis of the curricular material

From a curriculum development standpoint:

Problem solving curricular material that emphasizes metacognition may not be adopted by physics instructors
Implications

- Instruction is needed to help students develop their [metacognitive] processes while emphasizing the important role that these processes play in problem solving.
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From a curriculum development standpoint:

So, either that curricular material must match instructors’ values, or that instructors must be convinced of the value of emphasizing metacognition.
Implications

- Instruction is needed to help students develop their [metacognitive] processes while emphasizing the important role that these processes play in problem solving.
- Original hypothesis: Instructors do not adopt curricular material due to a mismatch between their beliefs and values and the emphasis of the curricular material.

From a curriculum development standpoint:

*In either case, we need to find out more about instructors’ beliefs and values about the teaching and learning of problem solving in physics!!*
The End

Please visit our website for more information:

http://groups.physics.umn.edu/physed/

Or send Email to:

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