Solving a Physics Problem – An Expansion of Instructors’ Beliefs*

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Overview of Study

Exploratory Study – Small Sample

• Initial model based on 6 UMN faculty

• Refine and expand the initial model based on interviews with 24 faculty from different institutions

• Determine the distribution of conceptions among faculty using a larger national sample

• Sharpen understanding using an international sample

Focused Study – Large Sample

Previous Talk
Overview of Study

Exploratory Study – Small Sample

Previous Talk

• Initial model based on 6 UMN faculty

Focused Study – Large Sample

• Refine and expand the initial model based on interviews with 24 faculty from different institutions (Community College, Private College, State University).

Current Study

• Refine and expand the initial model based on interviews with 24 faculty from different institutions (Community College, Private College, State University).

Future

• Determine the distribution of conceptions among faculty using a larger national sample

• Sharpen understanding using an international sample

• PERC Proceedings (2001)
• PERC Proceedings (2002)
• Henderson Dissertation (2002)
Now ...

We have interviewees that teach in different situations

- Are there similarities / differences in their conceptions of the process of solving physics problems in the context of an introductory physics course?
Targeted Analysis

Analyzing interviews are very time consuming

6 interviews → 24 interviews

Target a feature of the initial model and cut down the analysis time

• **Problem-solving process** (least coherent & most puzzling)
• **Identify** parts of interview where statements about the problem-solving process were found in previous study
• **Analyze** additional interviews
  – Code only statements regarding the problem-solving process
  – Generate problem-solving process concept map for each individual interview
• **Compare** the new conceptions with initial model (7 randomly selected, non-research university faculty)
Previous Study

• 3 Conceptions

  1. Linear Decision-Making

  2. Exploration and Trial & Error

  3. Creative process
The Problem Solving Process
Conception 1: Linear decision-making (RU)

① Quantitative Analysis
② Qualitative analysis
③ Answer
④ Evaluate Answer

• “Know” principle(s) to use
• Clarify thinking

Solution
**The Problem Solving Process**

Conception 1: Linear decision-making (5 of 7)

1. **Qualitative Analysis**
   - Visualize the problem
   - Think about the situation in terms of relevant physics principles
   - Identify relevant information

2. **Quantitative analysis**

3. **Answer**

4. **Evaluate Answer**
   - By constructing mental images from the text, such as having pictorial representations of the problem situation
   - Based on the pictorial representations, select relevant physics principles that are involved from recognizing similarities to previously solved problems
   - Based on the relevant physics principles, identify from the problem the necessary known and unknown information

Solution
The Problem Solving Process
Conception 1: Linear decision-making (5 of 7)

1. Qualitative Analysis
   - Make and decide on assumptions, if necessary
   - Apply principles at points of interest
   - Implement mathematical tools

2. Quantitative Analysis

3. Answer

4. Evaluate Answer
   - By asking, “is there any additional information that is needed?”
   - By implementing relevant physics principles at appropriate places in the problem situation
   - To utilizing the equations associated with the physics principles

By implementing relevant physics principles at appropriate places in the problem situation

Algebra, Calculus, etc …
The Problem Solving Process
Conception 1: Linear decision-making (5 of 7)

1. Qualitative Analysis
2. Quantitative analysis
3. Answer
4. Evaluate Answer

- Check units of final answer
- Evaluate reasonableness of answer
- Evaluate reasonableness of assumptions

By asking, “does the unit for the final answer match the measure that was supposed to be solved for in the problem?”

By asking, “is it what’s needed to be solved? Are the magnitudes correct based on personal knowledge of the world?”

By asking, “are the reasons for the assumptions valid?”
The Problem Solving Process

Conception 2: Exploration (RU)

1. Qualitative analysis
   - Explore the problem

2. Quantitative Analysis
   - Come up with possible approaches to try
   - Try most promising approach

3. Answer

Solution
The Problem Solving Process

Conception 2: Exploration (1 of 7)

Check Progress

① Qualitative analysis

② Quantitative Analysis

③ Answer

By reading the problem carefully to know what the problem is asking (i.e., translating the words of the problem statement)

By recognizing that there may be several principles & techniques (approaches) that may apply to the problem situation

By having an idea about what relevant steps, from the applicable set of principles & techniques, may lead closer to the answer

• Understand the problem situation

• Think about principles & techniques that may apply

• Have possible outline in mind of how to start the problem
The Problem Solving Process

Conception 2: Exploration (1 of 7)

Check Progress

① Qualitative analysis

② Quantitative Analysis

③ Answer

By having an idea in mind of what steps may lead closer to an answer, one checks to see if the approach undertaken is progressing towards that end

Based on recognition of similarities with previously solved problems

- Try most promising approach
- If the approach doesn’t result in progress towards an answer, use another approach
Conception 3: Art form

Solving Physics Problems

1. Know how to approach it (2, 4)
2. Focus on separating the data from the story (75)
3. Like free writing, where you don't care about grammar, just want to get the ideas down, and organize later (81)
4. Drawing pictures / diagrams (13, 26, 30, 40, 47, 48, 53, 56, 58, 64)
5. Listing known and unknowns (22, 96)
6. Listing concepts and possible concepts (25, 29, 54, 56, 57)
7. Understanding major concepts (9, 19, 78, 91, 93)
8. Basic principles (49, 60)
9. Organization (14, 26, 27, 39, 45, 46, 53, 59, 67, 84, 92)
10. Equations (25)
11. Explanations of the concepts (27)
12. Evaluating solution (50)
13. Focusing on getting the right answer (11, 77)
14. Reflecting on the technique (12)
15. Evaluating mistakes on scratch paper (15, 16)
16. Struggles (15, 16, 34)
17. Dead ends (15, 16, 84)
18. More than one concept (18, 23, 71, 86)
19. More like exercises (43)
20. Solving exercises (1, 4)
21. Where
22. Try solving (24, 36)
23. Time to go back (3, 11, 12, 24, 36)
24. Thought about the process (11, 24, 36, 77)
25. Reflecting on the technique (12)
26. Plugging in the numbers (28)
27. Trying to solve (24, 36)
28. One should spend most of the time (32, 33, 36, 55)
29. There is usually lots of
30. require lots of
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The Problem Solving Process

Inst 6: Solve Physics Problems

Inst 28: Solving Physics Problems

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The Problem Solving Process
Conception 3: Creative Process (RU)
While reading the problem, concentrate on separating the relevant information from the “story”

Brainstorm ideas about principles and techniques

By coming up with possible ways to approach the problem without knowing if any approach will lead to an answer
Using various techniques (e.g., drawing pictures & diagrams, listing concepts & possible concepts, etc.) and try to solve the problem – making lots of sketches and calculations …

- Analyze
- Organize

(e.g., Painting – draw rough sketch, then organize the mess; Free Writing – write down every relevant idea, then organize)

Because, by organizing the communication, one organizes one’s own thoughts

If the attempt does not lead to an answer, go back to brainstorming other approaches and redo the analysis
The Problem Solving Process
Conception 3: Art form (1 of 7)

1. Qualitative Analysis
2. Quantitative analysis
3. Answer
4. Evaluate Answer

Back & forth

By asking, “does the it answer the question?”

If it does not answer what the problem is asking, take time to go back and redo the brainstorming and analysis

Evaluate answer
In the description of the process of solving physics problems (Research & Non-Research University Faculty):

**Similarities**
- 3 Conceptions
- Units of Problem Solving
  - Qualitative analysis
  - Decision about approach
  - Implementation of techniques (math, diagrams, etc …)
  - Evaluation of process &/or answer

**Differences**
- More descriptive details of the problem solving process
- Order of some of the steps
On-going hypothesis generation …

1. Supported the initial model with instructors from different settings
   - Are there only a few ways that physics faculty think about the process of problem solving in physics?
   - If so, A smaller number of variations is easier to handle for:
     1) developing appropriate curricular material
     2) providing proper professional development!
2. Faculty conceptions are more detailed for this population

– Does this level of complexity depend on the type of institution?

1) Agreement with expert-novice problem solving research – need less professional development!

2) Disagreement with expert-novice problem solving research – more difficult to design proper professional development!
The End ...

For more information, visit our web site at:

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