

## 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 **L** 

#### **Overview of Study**

Exploratory Study – Small Sample

Previous Talk

• Initial • model based

on 6 UMN faculty

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

Focused Study – Large 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** Physics Inst 3: Solve Physics Problems first requires Careful analysis of the Deener understanding of steps, multiple physics The problems are how to relate variables in Reading and and topics, and a synthesis of different situations to solve difficult and more understanding more difficult problems (93, the problem (45) involved (94) 98 99) solvina and physics Inst 27: Solving Physics Problems Starting in a problems approach (76 (13) 78 85) that starts involves Good Focus the that starts rganization (77 problem (19) 100, 106, 112) Drawing a diagram Coordinate and have that represents the rigin (21, 22, 23) situation (15, 16, 55, that include 142, 149) Specifically identify what Good pictures (17. Make a list of knowns Indicate how to known and what needs because it help 18, 28, 29, 30, 44 and unknowne (15 proceed (79. to found/calculated (34 to (18) 46, 47, 76, 77, 80) 16, 20, 31, 32, 34, 35) 83) and then 35, 48, 79) that include and then to help FBD (26, 27 can be aided by Reflect or 28, 29, 30) (15, 17)Make connections identifying the contemplate (49 101, 107, 108, 113) between what is known fundamental concepts and what needs to be found (33) involved (15, 17, 55, Writing down of 143, 149, 342) thinking about the reasoning for each step (55, 57, 58) Think about the include underlying physics and then carefully (50, 51, 113 114) An requires derstanding o before physics (102) determine chain of in introductory Applying physical laws reasoning to get from what Make at certain points of where it is Justify them physics is often assumptions nterest (14, 76, 77, 81, is being asked to the steps important to (37) (36) appropriately vou will use (15, 19, 20, 21, done by and then What's written down 22, 55, 80, 85, 147) Decide which depends on how the vav to go (63) olution started (65) Write down and then ations carefully Writing down what's (62, 103, 114) Determine if the Look over at what's been considered in unknowns can be given knowns and mathematical form while at the solved by using the unknowns (66) (63, 64) equations (67) same time work through symbolically to the which should -Evaluating solution (15, 149) where they're at (68, 69)

Catch errors

Experience

should allow

students to

based on their

Evaluate and estimate the

reasonability of the answer

solved (70, 71, 72, 73, 110,

Decide which is the most mathematically efficient way (68, 69)

to get to

The answer

determining exactly

what is being asked

(15, 17, 342)

and

recognizing what

kind of problem it

is (119)

working

backwards (23,

be checked for

proper dimensions

(132, 133)

and then

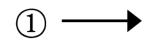
put in numbers at the end (15,

25, 26)



**Conception 1: Linear decision-making (RU)** 





2

Qualitative

analysis



Answer



**Evaluate Answer** 



"Know" principle(s) to use

Quantitative

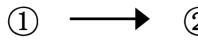
**Analysis** 

Clarify thinking



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











Qualitative Quantitative Analysis analysis

Answer

Evaluate

Answer



- Visualize the problem
- Think about situation in terms of relevant physics principles
- Identify \_\_\_\_\_relevant information

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 problem the necessary known and unknown information



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



(1)

2

 $\longrightarrow$ 

3

4



Qualitative Analysis **Quantitative** analysis

Answer

**Evaluate Answer** 

By asking, "is there any additional information that is needed?"

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

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

Algebra, Calculus, etc ...

To utilizing the equations associated with the physics principles



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



Quantitative Qualitative **Analysis** analysis

Answer

**Evaluate** 

**Answer** 



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?"

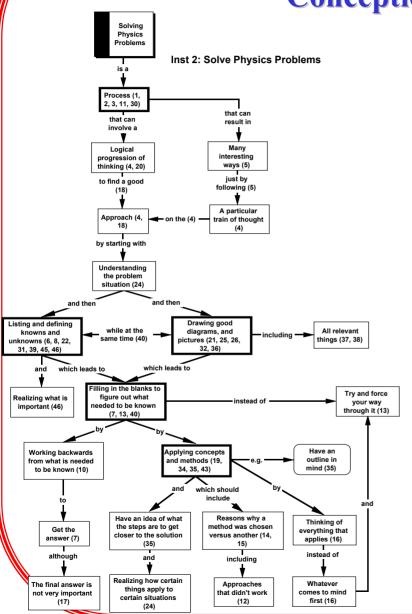
> By asking, "are the reasons for the assumptions valid?"

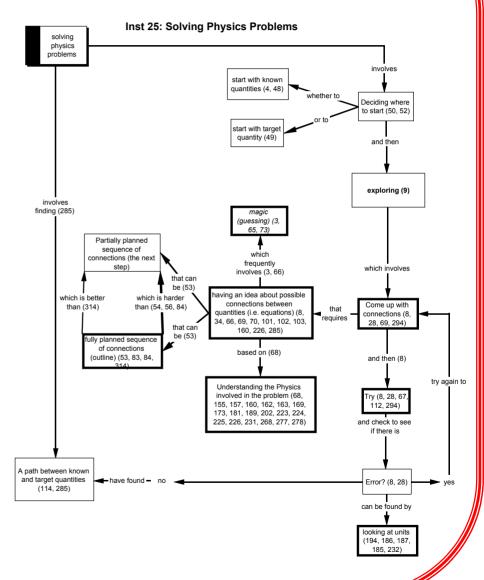
- Check units of final answer
- Evaluate reasonableness of answer
- Evaluate reasonableness of assumptions

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#### The Problem Solving Process

**Conception 2: Exploration** 





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#### **The Problem Solving Process**

Conception 2: Exploration (RU)



①
Qualitative
analysis

Quantitative Analysis

3

Answer



- Explore the problem
- Come up with possible approaches to try
- Try most promising approach

#### **L**

#### **The Problem Solving Process**

**Conception 2: Exploration (1 of 7)** 



**Check Progress** 

2

Quantitative

**Analysis** 

3

Answer



Understand the problem situation

Qualitative

analysis

- By reading the problem carefully to know what the problem is asking (i.e., translating the words of the problem statement)
- Think about principles & techniques that may apply

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

Have possible outline in mind of how to start the problem

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



**Conception 2: Exploration (1 of 7)** 



**Check Progress** 

(1)

Qualitative analysis



Analysis

3

Answer



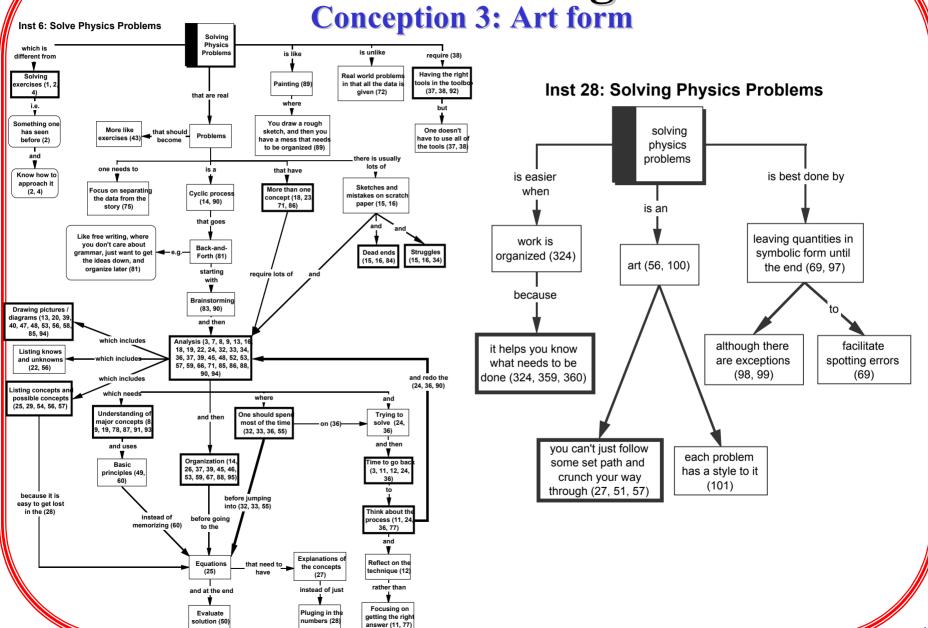
Based on recognition of similarities with previously solved problems

- Try most promising approach
- If the approach doesn't result in progress towards an answer, use another approach

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

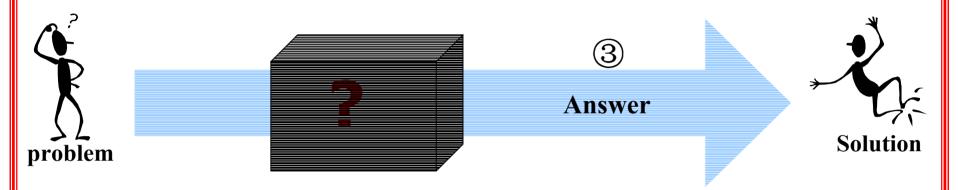
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#### The Problem Solving Process





### The Problem Solving Process Conception 3: Creative Process (RU)





**Conception 3: Art form (1 of 7)** 

Back & forth









Answer



**Evaluate** 

**Answer** 



Qualitative **Analysis** analysis

 While reading the problem, concentrate on separating the relevant information from the "story"

• Brainstorm ideas about principles and techniques

Read carefully

By coming up with possible ways to approach the problem without knowing if any approach will lead to an answer



**Conception 3: Art form (1 of 7)** 

Back & forth



Qualitative

Analysis



**Evaluate 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)

If the attempt does not lead to an answer, go back to brainstorming other approaches and redo the analysis

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



**Conception 3: Art form (1 of 7)** 

Back & forth



Qualitative

**Analysis** 

Quantitative analysis

Answer

**Evaluate** 

Answer

**Solution** 

By asking, "does the it answer the question?"

**Evaluate answer** 

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



#### So ...

# 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 the process of problem solving in physics?



A smaller number of variations is easier to handle for:

- 1) developing appropriate curricular material
- 2) providing proper professional development!

### On-going hypothesis generation ...

- 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!

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#### The End ...

For more information, visit our web site at:

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