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

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Overview of Study

Exploratory Study – Small Sample

Previous Talk

- 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

Overview of Study

Exploratory Study – Small Sample

Previous Talk

- Initial model based on 6 UMN faculty

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

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

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)

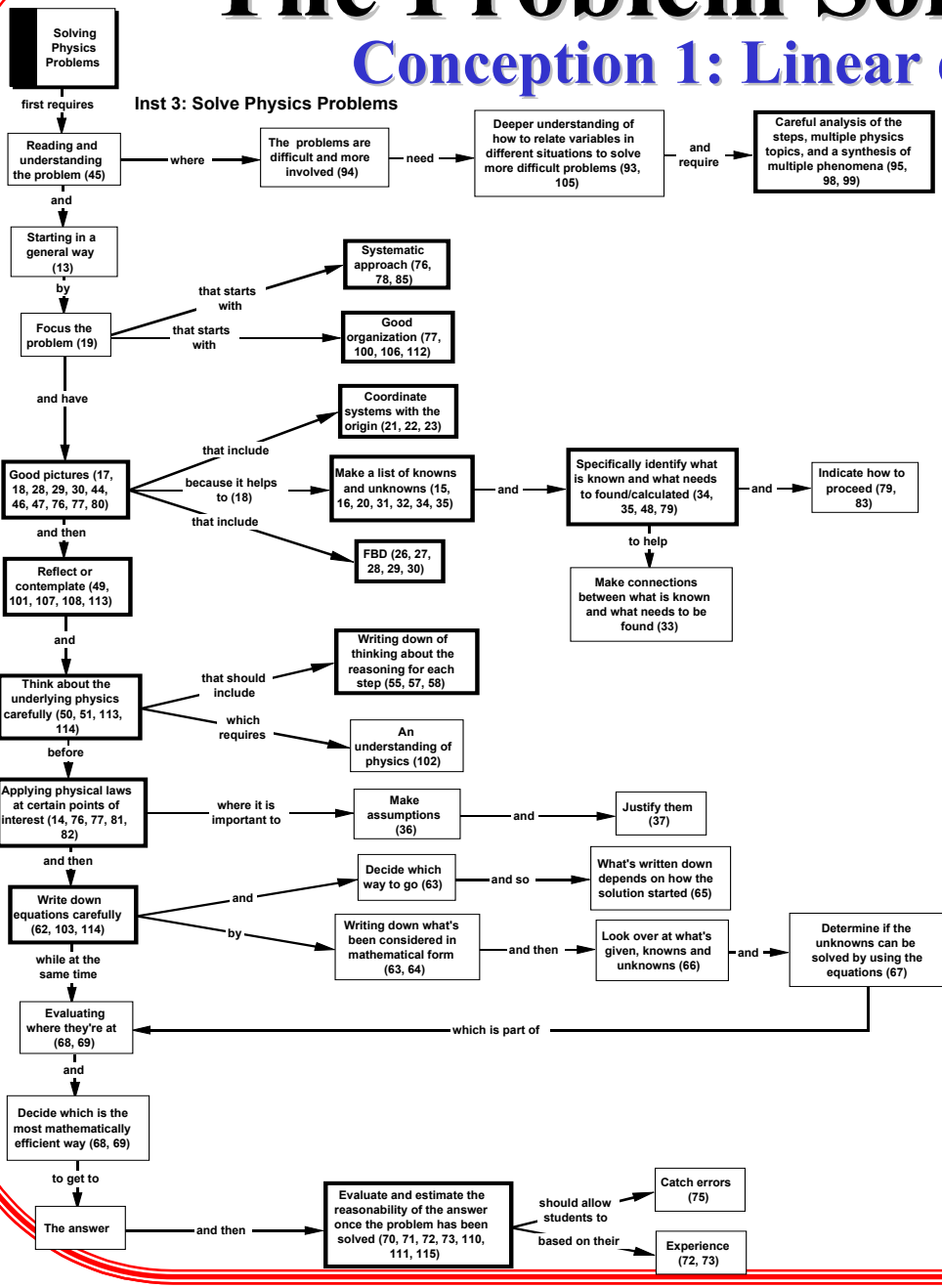
Previous Study

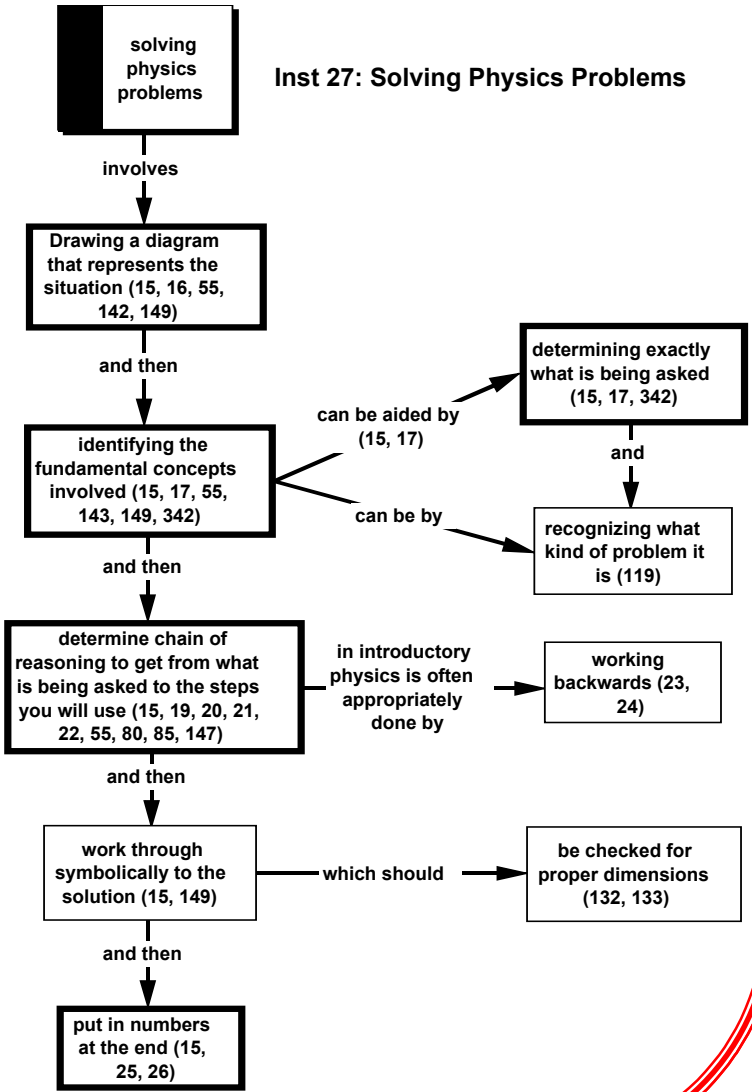
- **3 Conceptions**

1. **Linear Decision-Making**
2. **Exploration and Trial & Error**
3. **Creative process**

The Problem Solving Process

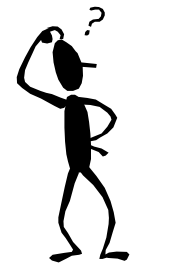
Conception 1: Linear decision-making





The Problem Solving Process

Conception 1: Linear decision-making (RU)



problem

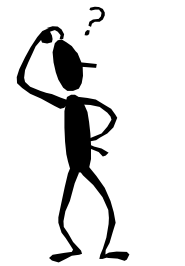
① Quantitative Analysis → ② Qualitative analysis → ③ Answer → ④ Evaluate Answer

Solution

- "Know" principle(s) to use
- Clarify thinking

The Problem Solving Process

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



problem

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

Solution

- Visualize the problem

By constructing mental images from the text, such as having pictorial representations of the problem situation

- Think about situation in terms of relevant physics principles

Based on the pictorial representations, select relevant physics principles that are involved from recognizing similarities to previously solved problems

- Identify relevant information

Based on the relevant physics principles, identify from problem the necessary known and unknown information

The Problem Solving Process

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

problem

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

Solution

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

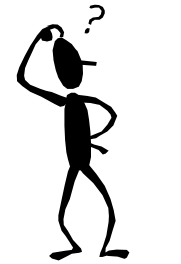
By implementing relevant physics principles at appropriate places in the problem situation

To utilizing the equations associated with the physics principles

Algebra, Calculus, etc …

The Problem Solving Process

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



problem

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

Solution

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

- Check units of final answer

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

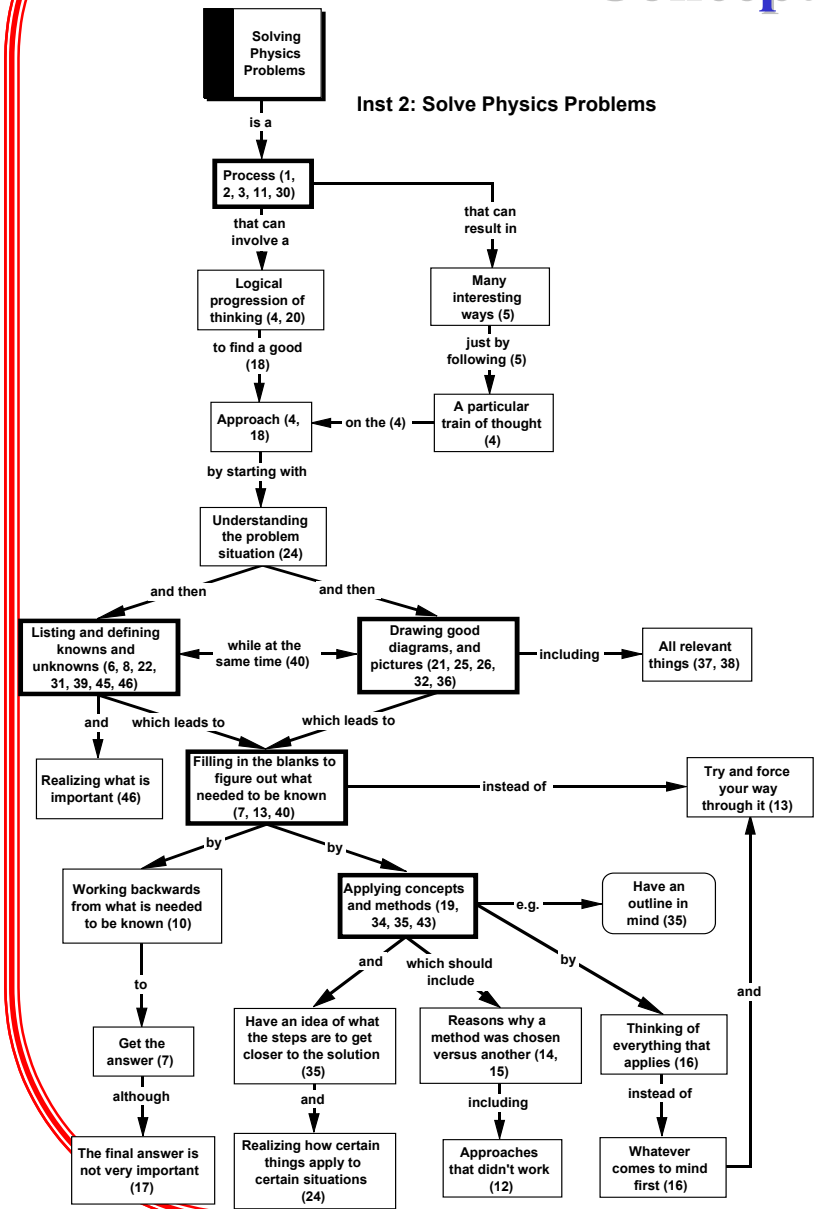
- Evaluate reasonableness of answer

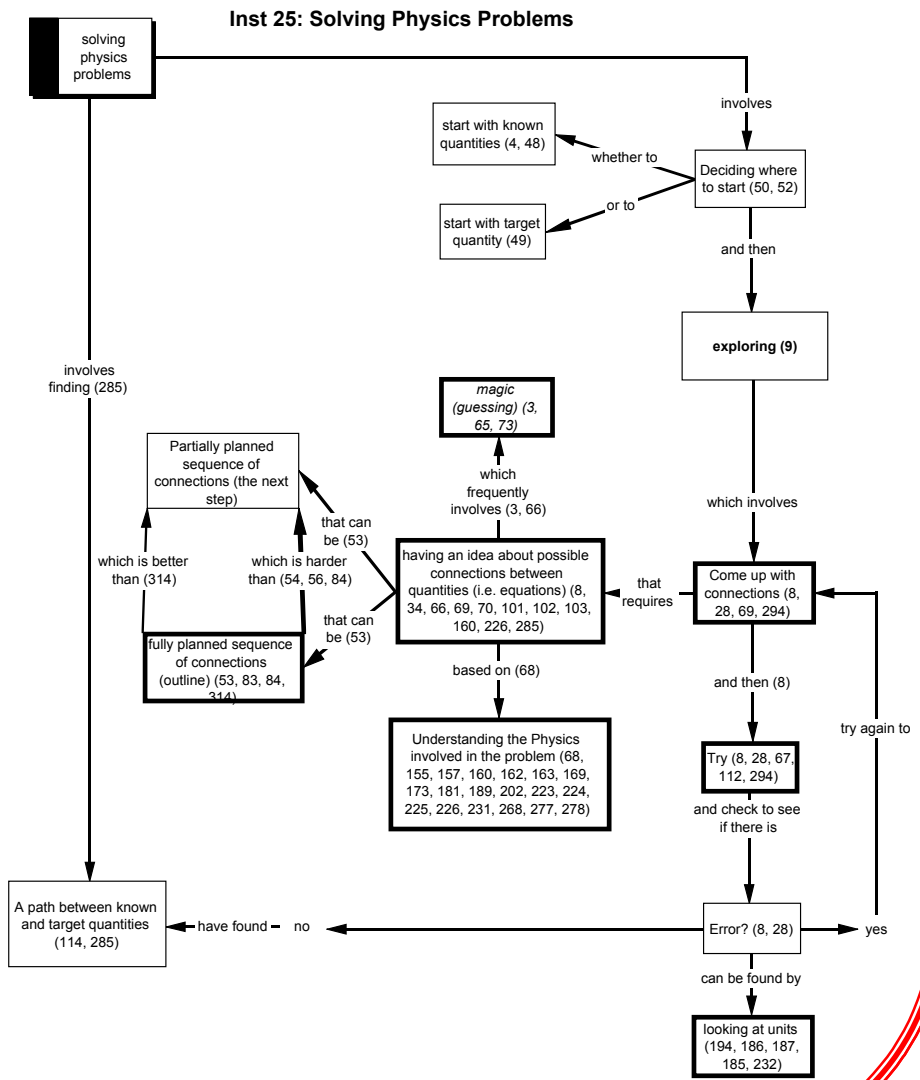
By asking, "are the reasons for the assumptions valid?"

- Evaluate reasonableness of assumptions

The Problem Solving Process

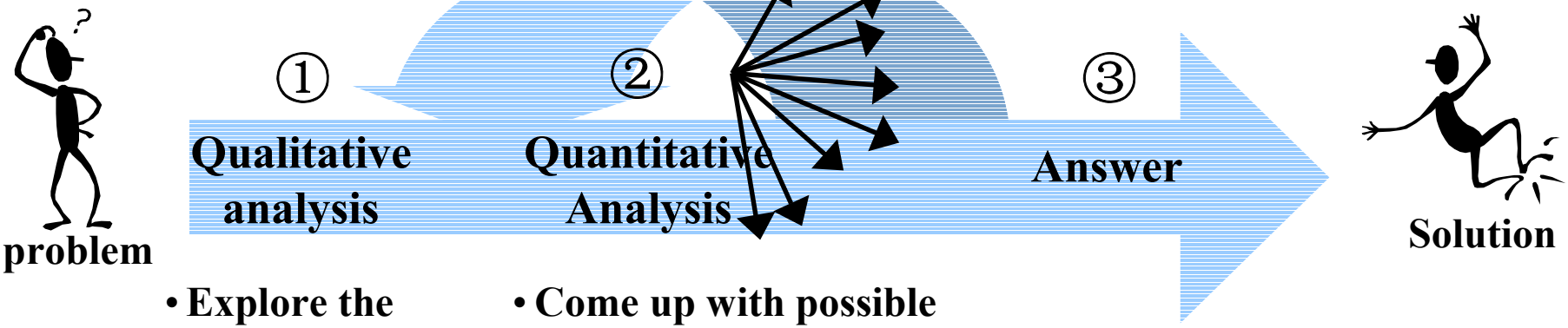
Conception 2: Exploration





The Problem Solving Process

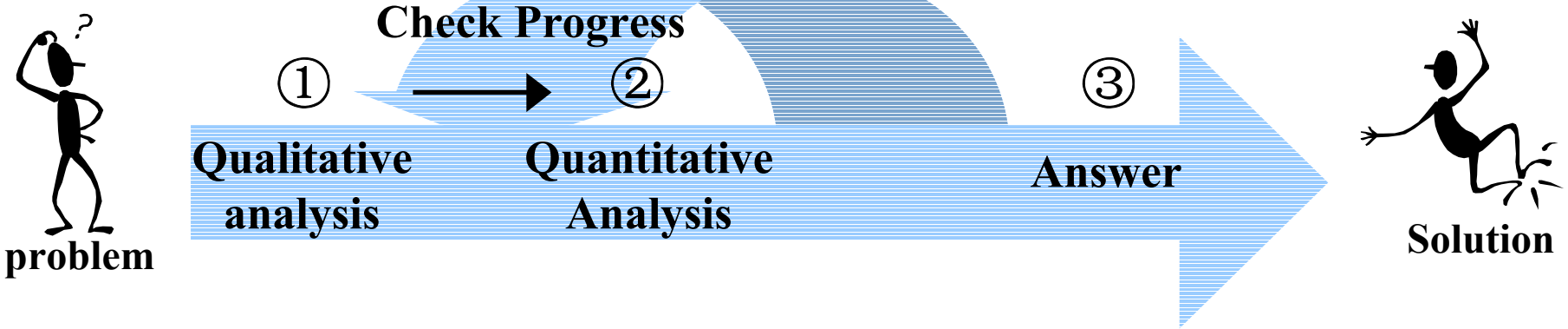
Conception 2: Exploration (RU)



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

The Problem Solving Process

Conception 2: Exploration (1 of 7)



- Understand the problem situation

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

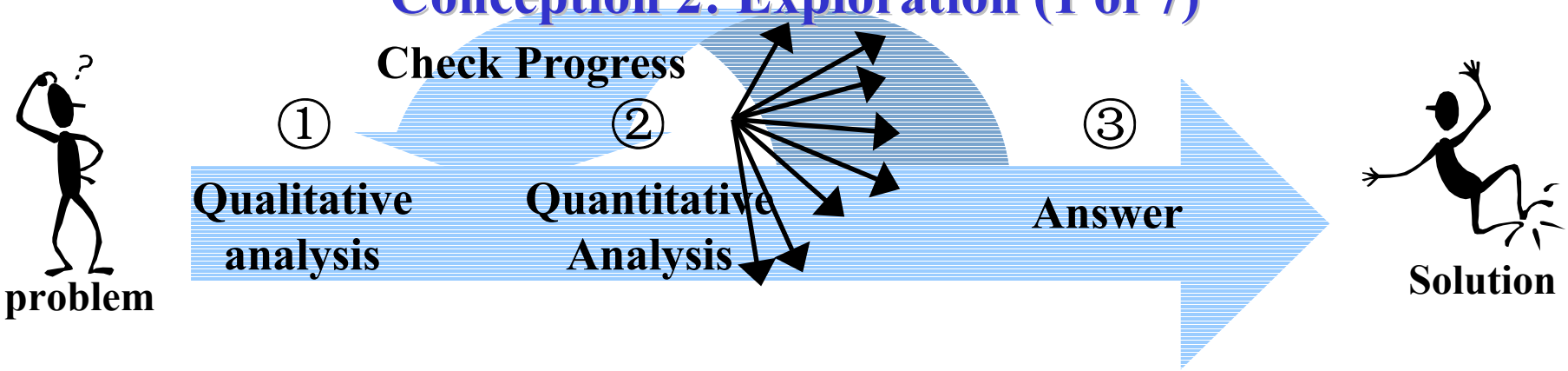
By recognizing that there may be several principles & techniques (approaches) that may apply to the problem situation

- 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

The Problem Solving Process

Conception 2: Exploration (1 of 7)



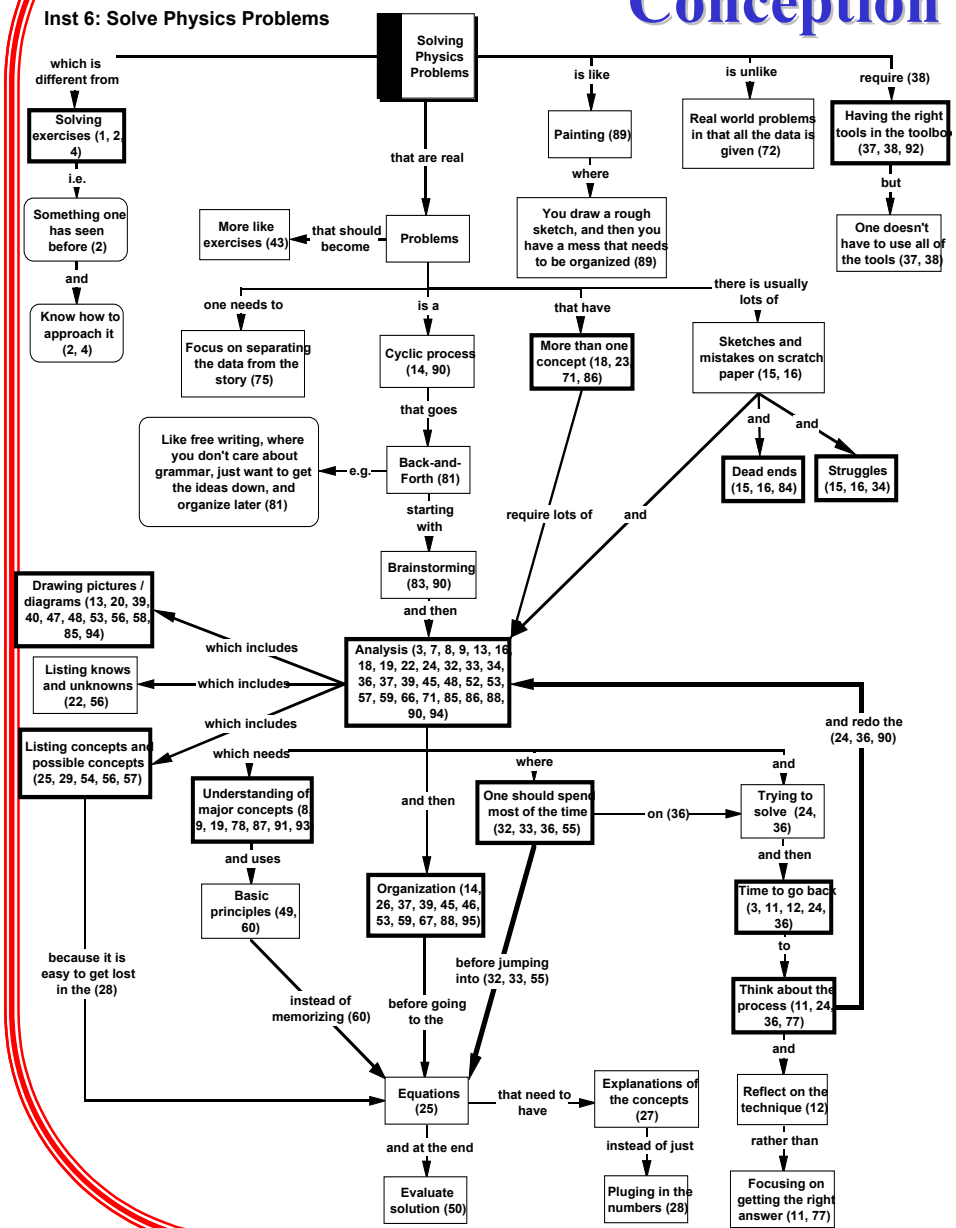
Based on recognition of similarities with previously solved problems

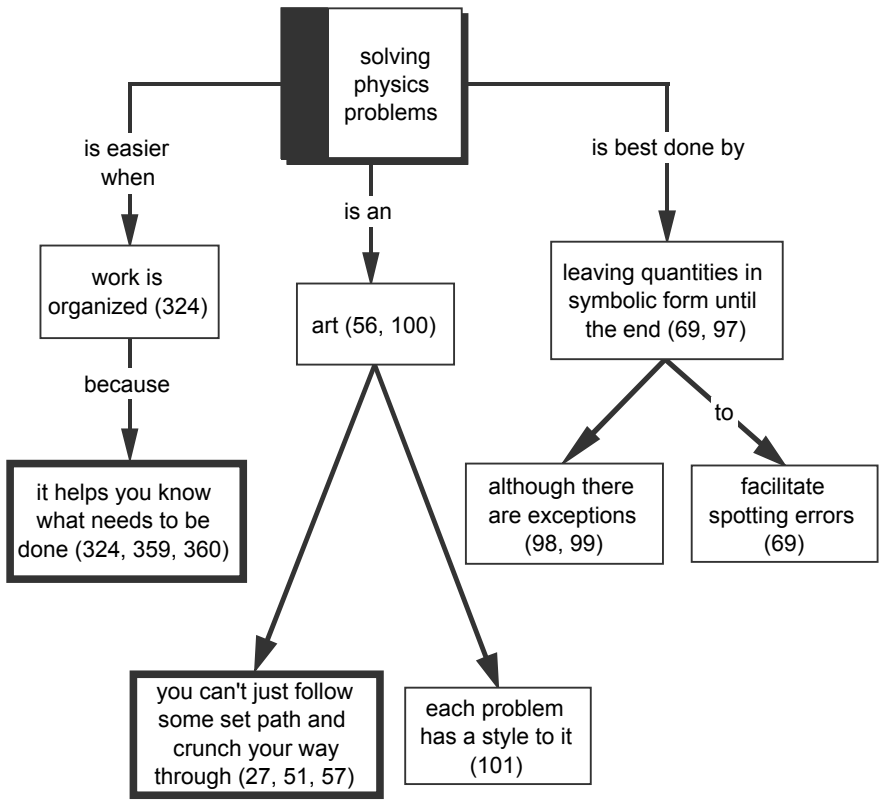
- Try most promising approach
- If the approach doesn't result in progress towards an answer, use another approach

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

The Problem Solving Process

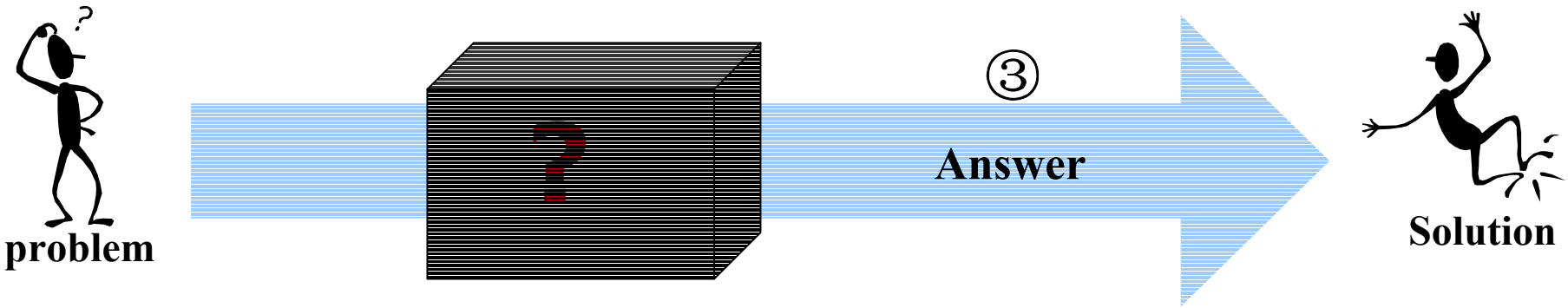
Conception 3: Art form





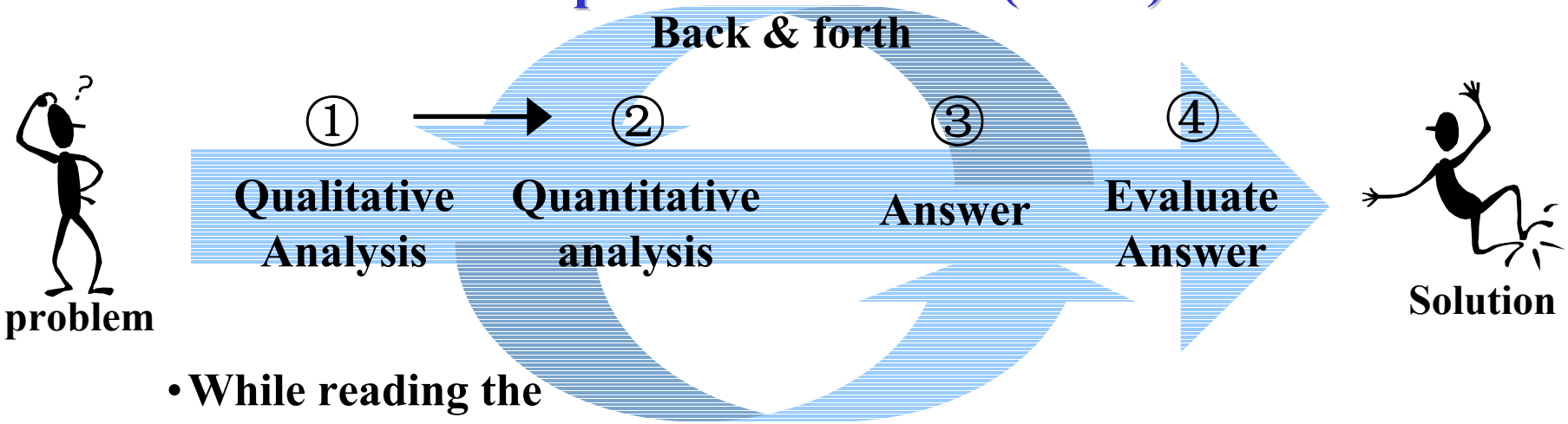
The Problem Solving Process

Conception 3: Creative Process (RU)



The Problem Solving Process

Conception 3: Art form (1 of 7)



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

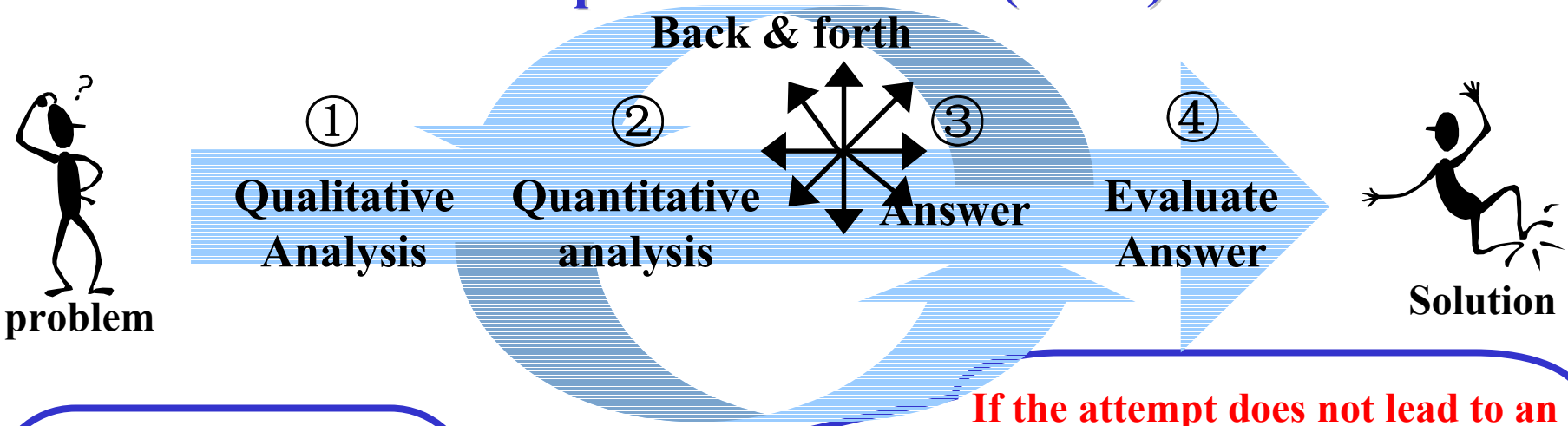
Read carefully

- 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

The Problem Solving Process

Conception 3: Art form (1 of 7)



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

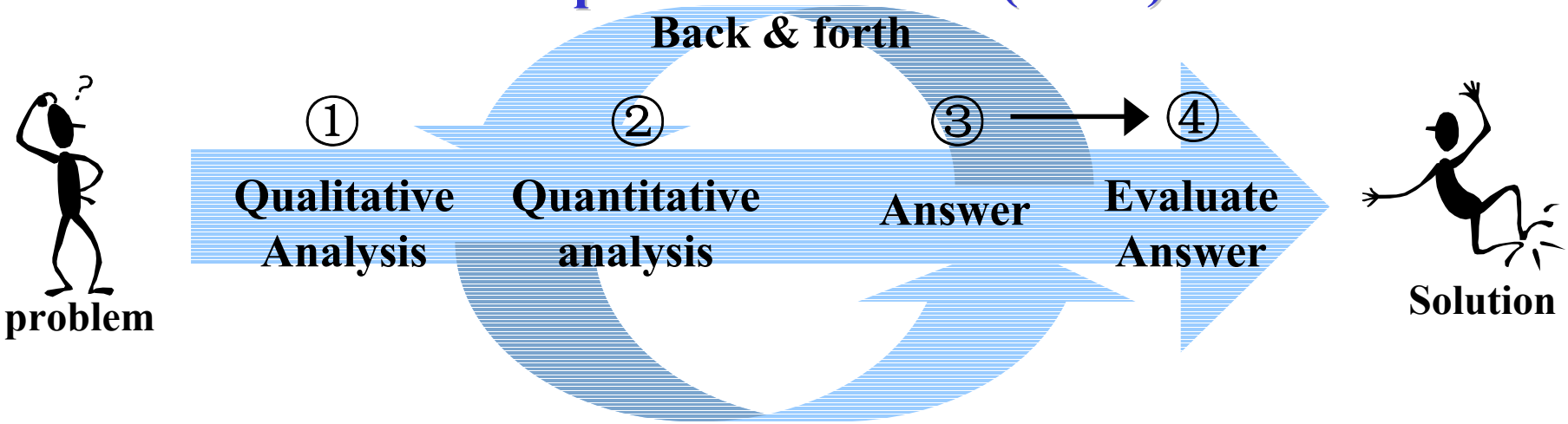
(e.g., Painting – draw rough sketch, then organize the mess; Free Writing – write down every relevant idea, then organize)

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

The Problem Solving Process

Conception 3: Art form (1 of 7)



- Evaluate answer

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

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 …

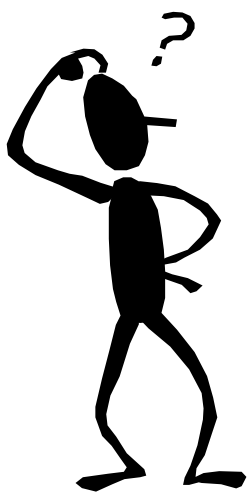
1. **Supported the initial model with instructors from different settings**
   - **Are there only a few ways that physics faculty think about the the process of problem solving in physics?**
   - **If so,**

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!

The End …

For more information,
visit our web site at:

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

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