What Does it Mean to Solve a Physics Problem? – Instructors' Beliefs *

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Overview

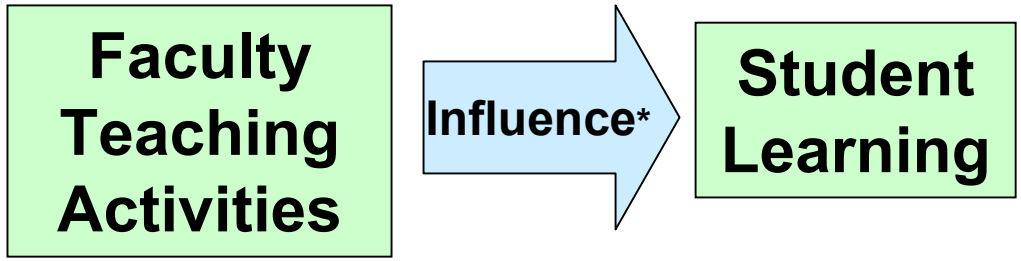
1. Why study faculty conceptions?
2. Overview of larger study.
3. What conceptions do six research university faculty have about the process of solving physics problems (in the context of introductory physics).

Why are Faculty Conceptions Important?

Want to Improve **Student Learning**

*e.g. Prosser & Trigwell (1999), Understanding Learning and Teaching

Why are Faculty Conceptions Important?



1. Selection of teaching approach
2. Selection of teaching materials
3. Evaluation of teaching

*e.g. Prosser & Trigwell (1999), Understanding Learning and Teaching

Why are Faculty Conceptions Important?

1.Subject (i.e., knowledge and beliefs about the subject they are teaching)

2.Teaching and Learning (e.g., pedagogical knowledge, orientation towards teaching)

3.Context (e.g., perceptions of student capabilities, perceptions of administrative constraints)

1. Selection of teaching approach
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Focus of This Talk

Faculty Conceptions

1.Subject (i.e., knowledge and beliefs about the subject they are teaching)

2.Teaching and Learning (e.g., pedagogical knowledge, orientation towards teaching)

3.Context (e.g., perceptions of student capabilities, perceptions of administrative constraints)

Faculty knowledge and beliefs about the problem solving process

Influences

- How they model/explain problem solving to students
- How they expect students to solve problems
- How they expect students to learn how to solve problems
- Their attitudes towards curricular materials

Who Needs to Understand Faculty Conceptions?

Curriculum Developers Need to Understand Faculty Conceptions:

- Instructional materials and/or strategies may not align with faculty conceptions:
  - Non Use by faculty
  - Inappropriate Use by Faculty

Professional Development Providers Need to Understand Faculty Conceptions:

- Identify faculty strengths (build on p-prims)
- Identify "gaps" in faculty conceptions (help bridge gap)
- Identify conflicting conceptions (promote disequilibrium)

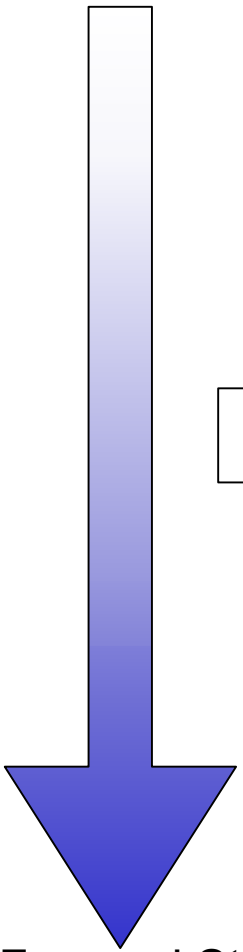
Goal of this Study

- Begin the process of building a model of faculty conceptions (beliefs and values) about the teaching and learning of problem solving in introductory calculus-based physics based on interviews with physics instructors.
  - Can (how can) faculty conceptions be measured?
  - Can (how can) a model be constructed to describe these conceptions?
    - What are the major features of this model?
    - How are these features related?

The focus of this study is on problem solving because the Physics Education Research Group at UMN is interested in problem solving.

Overview of Study

Exploratory Study – Small Sample



Focused Study – Large Sample

Current Talk

- **Initial model based on 6 UMN faculty.**

Next Talk

- **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.**

The Problem Solving Process

six research university instructors

Conception 1: A linear decision-making process (backtracking is not necessary) (3 of 6)

Step 1: "Know" physics principle(s) to use

Step 2: Clarify thinking (e.g. by using diagrams)

Step 3: Use tools (e.g., algebra, FBD) to get answer

Step 4: Evaluate answer

Conception 2: A process of exploration and trial and error process (2 of 6)

Step 1: Decide on goal (e.g., target to known)

Step 2: "Explore" the problem and "decide" on possibly useful approaches or principles

Step 3: Try most promising approach

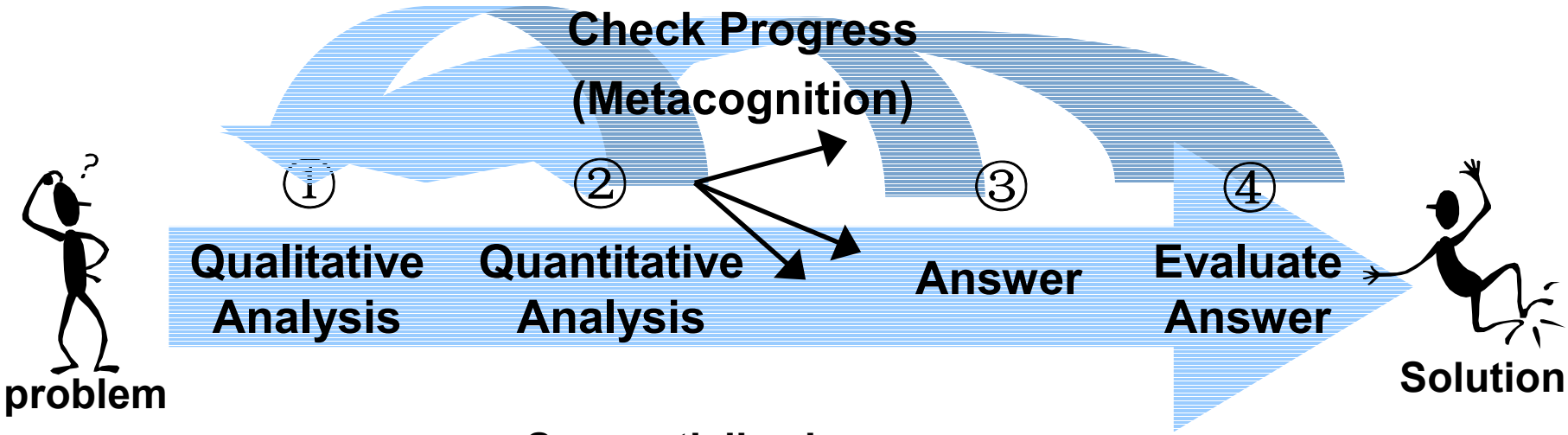
Step 4: Evaluate progress (return to step 2 if necessary)

Conception 3: A creative process that is different for each problem (1 of 6)

(no process given)

The Problem Solving Process

the Cognitive Psychology perspective*



- Visualize what is happening
- Identify Options (e.g., principles or definitions)
- Draw diagrams
- Identify goal

- Sequentially choose sub problems that reduce the gap between goal and known information
- Implement

For experts, choices limited by:

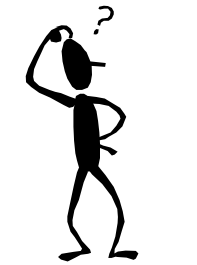
1) knowledge structure
2) experience

- Goal attained?
- Well specified?
- Self consistent? (units, signs)
- Consistent with other information? (e.g., special cases)
- Optimal? (as clear and simple as possible)

*Based largely on Reif (1995) in AJP & Polya (1957) in *How to Solve it*

The Problem Solving Process

Conception 1: A linear decision-making (3 instructors)



② ? ③ ④

Quantitative Analysis → Answer → Evaluate Answer

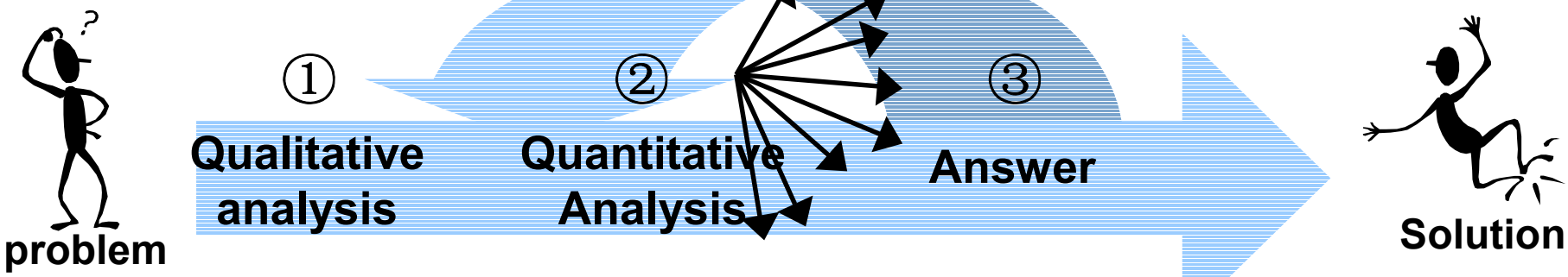
- "know" principle(s) to use
- Implement

? – How are the correct physics principles selected?

The Problem Solving Process

Conception 2: A process of exploration and trial and error

(2 instructors)



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

?

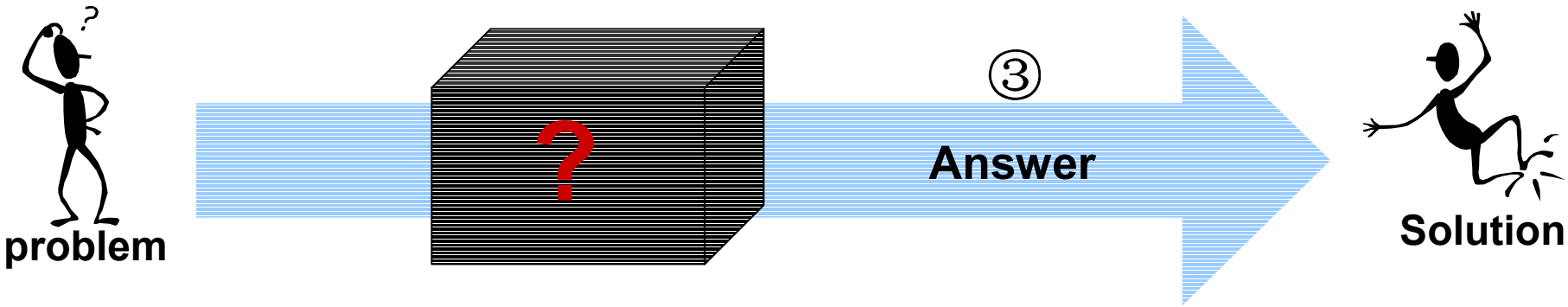
Options limited by:

1) Well organized knowledge structure
2) Ability to recognize similarities with previously solved problems

? – How are the number of possible approaches limited?

The Problem Solving Process

Conception 3: A creative process that is different for each problem (1 instructor)



Conclusions

There are similarities between the Cognitive Psychology view of the PS process and the five instructors who identified a process:

- **Main "units" of the problem solving process are similar.**
  - **Qualitative analysis/clarification phase**
  - **Decision about approach/principles**
  - **Implementation**
  - **Evaluation**
- **Although the ordering and some details were different.**

Conclusions

There are differences between the Cognitive Psychology view of the PS process and the five instructors who identified a process:

- Main difference is the identification of choices in decision making

No choices – predetermined (algorithm)

Instructors not familiar with expert/novice PS research

Infinite choices (random)

Linear Decision Making (3 instructors)

Experience is everything

Strategic Decision Making

• Knowledge Structure
•Strategy

Trial & Error (2 instructors)

Monitoring progress is everything

Implications for Curriculum Developers

No choices – predetermined (algorithm) ⟷ **Infinite choices (random)**

	Linear Decision Making (3 instructors)	Strategic Decision Making	Trial & Error (2 instructors)
Teaching Activity	Instruction likely to emphasize error-free and mechanical performance	Instruction likely to emphasize knowledge organization and PS strategy	Instruction likely to treat making choices as "magic"
Curricular Material	Lots of "Drill & kill" single concept problems	PS Strategy, Framework for organizing and using physics knowledge	Strategy for evaluating progress

Implications for Professional Development Providers

1. There are things to build on: basic building blocks of problem solving process are there.
2. There are opposite views.
   - Good situation for professional development.

No choices – predetermined (algorithm)

Infinite choices (random)

Linear Decision Making (3 instructors)

PER – Strategic Decision Making

Trial & Error (2 instructors)

The End

**For more information,
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