Instructor’s Beliefs and Values about Students Learning Problem Solving

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From Questions to Hypotheses

1: Do physics professors have common beliefs about how students learn to solve problems in introductory physics?

2: How do instructor’s ideas match with standard instructional paradigms?

3: What are the implications for curriculum developers?
Calibration Sample

6 professors from a large state research university.

Known constraints and practices
Calibrate interview data with reality

Teaching Environment

• 3 lectures/wk – calculus-based intro physics class (200 students)
• Graduate TAs – recitation and lab –
  • Cooperative Group Problem Solving
• TAs grade tests
• 1 meeting with TAs/wk.
• Physics Education Research Group exists – no direct contact
  • Cognitive Apprenticeship Instructional Models

Test hypotheses with 24 additional interviews
State Universities, Private Colleges, Community Colleges
Analyze faculty interview

3 Artifacts are discussed
• Instructor solutions
• Student solutions
• Problem types

3 Concrete Tasks
• Goals questionnaire (next talk)
• Grading student solutions (previous talk)
• Sorting statements about student problem solving

Analysis
• Link statements about how students learn to solve problems (30 pages of transcript/interview)
• Common pattern - composite concept map
Concept Map

- Learn
- Some college students
- Some college students can solve physics problems
- Reflective practice
- Improve other experiences
- From appropriate example problem solutions
- By working on problems
- To extract knowledge
- From connected Physics concepts
- Of Problem solving skills
- Of knowledge

Reflective practice by working on problems to extract appropriate example problem solutions can some college students learn solve physics problems, and this leads to improve other experiences.
Reflective Practice

- Reflective practice
  - to
  - extract
  - can happen when
  - working
  - knowledge
  - working in a group
    - because it involves
      - articulation of thinking and ideas
  - example problem solutions
    - from
      - in-class problems
    - and then
      - generalizing
        - and then
          - other people
            - by talking to
              - other students
              - instructor
              - by looking at
                - details
                - more general
                - can include
                  - figuring out what went wrong
                    - and
                      - stuck
                        - getting
                          - test/quiz problems
                          - can be
                          - HW problems
                          - can be
                          - getting
                          - correct answer
                          - can include
                          - incorrect answer
          - and
            - extracting
              - more general
              - rather than focusing on
                - specifics

General Features

• Students learn by doing
  There is no set way for solving problems
  Problem solving is idiosyncratic

• Students learn from others
  Groups
  Other individuals
  Problem solutions

• Learning requires metacognitive skills

Some features of the cognitive apprenticeship model of instruction.

Missing

Scaffolding instruction
Use of general heuristics
Instructional Paradigms

Rough check of concept map

- Project faculty statements onto these axes

Classify individual statements and count.
<table>
<thead>
<tr>
<th>Paradigm</th>
<th>Expert-Novice Difference</th>
<th>Instructional Mode</th>
<th>Teacher Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behaviorist</td>
<td>amount of knowledge</td>
<td>incrementally add knowledge to the learner</td>
<td>provide the knowledge carefully broken down into essential components</td>
</tr>
<tr>
<td>Developmental</td>
<td>usefulness of thinking organization (schemata). Schemata are ‘universal” and must be developed in a sequential hierarchy. A new schemata replaces an old one.</td>
<td>confrontation with contradictions to existing schemata (disequilibrium). The learner constructs the new schemata</td>
<td>provides series of activities to create disequilibrium by confronting the known old schemata. Provides activities to guide the learner to build the desired new schemata.</td>
</tr>
<tr>
<td>Cognitive Apprenticeship</td>
<td>interconnections among pieces of knowledge and their organization. Interconnections depend on previous experiences and can be significantly different from individual to individual.</td>
<td>construction and reorganization of knowledge interconnection. New experience interacts with old experiences.</td>
<td>shows expectations in a context that connects to the learner’s experiences (modeling). The learner attempts a similar task with assistance (coaching). Help is slowly removed so the learner accomplishes tasks on their own (fading).</td>
</tr>
</tbody>
</table>
Sample statements

Behaviorist. “These (UNDERSTANDING PHYSICS) are more “knowing the facts” and all that sort of stuff.” (amount of knowledge)

Developmental. “Of course some of these (DIFFICULTIES) depend on people. Some people you won’t get them to be systematic no matter how hard you try, they’re just not that organized to do that.” (organization of knowledge)

Apprenticeship. “To overcome difficulties, students have to solve problems without looking at solutions. And if they get stuck they should talk to someone specifically about what the next step would be, rather than looking at solutions, so they don't get too much help.” (interconnection of knowledge, coaching)
Statement Analysis

The chart illustrates the distribution of different statement types. The categories include:
- Behavioral
- Not Behavioral
- Developmental
- Not Developmental
- Apprenticeship
- Not Apprenticeship
- Unclassifiable

The percentages for each category are represented by bars. The Apprenticeship category has the highest percentage, followed by the Not Behavioral category. The Unclassifiable category has a relatively small percentage.
Physics faculty have common beliefs about how introductory physics students learn problem solving.

Faculty are closest to valuing an apprenticeship instructional model and furthest from a behavioral model.

Faculty believe metacognitive skills are necessary for students to learn problem solving.
To Be Continued

For more information, visit our web site at:

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