Use of Complex Problems in Teaching Physics

Tom Foster

Department of Physics

Southern Illinois University Edwardsville

Cooperative Group Problem Solving

- Having students solve the same task in structured, cooperative groups
- Five Key Elements of Cooperative groups
  - Positive interdependence
  - Individual accountability
  - Monitor interpersonal skills
  - Frequent Group Processing
  - Promotive Interactions

Appropriate Tasks

- If the problems are simple enough to be solved moderately well alone, then students will not abandon their independence to work with anyone else.
- If the problems are complex enough so the novice clearly fails but too complex so students are initially unsuccessful at working in groups, so the students will not abandon their independence to work with anyone else

Context-rich Problems

- Place the student in the problem: “You”
- No pictures if possible
- Full of decisions for students to make
  - Extra or missing information
  - No variable names
  - Hides the physics
- In the real or future world

Context-Rich Problems

- Closed-ended
  - Generally a few valid ways to solve problem
  - Rules of Mathematics and Laws of Physics dictate the solution paths
  - Balancing creativity with efficiency

Plausible Context

- Variety of situations where physics and problem solving is useful
- Explicitly modeling near transfer
- Optimal Adaptability Corridor
  - Schwartz, Bransford, and Sears (2005)
  - Balance efficiency with innovation
  - Creates adaptive experts

Challenges Naïve Problem Solving Ideas

- Naïve Ideas
  - Need “right” formula
  - Manipulate the math for any solution
  - Use all the given information, some how
- Context rich problems can be created to challenge each of these ideas

Difficulty

- Adding context can make a problem unsolvable even to the best group
- Students must be successful
  - Without success they won't learn.
  - But it can't come too easily.
- Difficulty of problem can be adjusted
  - The students or groups must succeed.

Difficulty Traits

- Approach
  - Cues lacking
  - Agility with Principles
  - Non-standard application
- Analysis of Problem
  - Excess, missing or “missing” information
- Mathematical Solution
  - Algebra or other complex math required

Context of Promising Practice

- Data supporting
  - High school physics classroom
  - College/University physics
    - Recitation / Lecture / Labs
    - Exams and Homework Assignments
- Found in Physics textbooks
  - Knight
  - Tipler and Mosca

Example

- While examining the engine of your friend's snow blower you notice that the starter cord wraps around a cylindrical ring. This ring is fastened to the top of a heavy, solid disk, "a flywheel," and that disk is attached to a shaft. You are intrigued by this configuration and decide to determine its moment of inertia. Your friend thinks you can add the moment of inertial by parts to get the moment of inertia of the system. To test this idea you decide to build a laboratory model described below to determine the moment of inertia of a similar system from the acceleration of the hanging weight.

Evidence

- Physics Mastery
  - Excellent performance on concept tests
- Skill development
  - Students problem-solving skill improve during class even as context changes
- Affective
  - Anecdotal
- Behavioral
  - Anecdotal

Assessments

- Problem-solving Skills
  - (1) Useful Description
  - (2) Physics Approach
  - (3) Specific Application
  - (4) Math Procedures
  - (5) Logical Progression
- Concepts
  - FCI, BEMA, etc.

Next Steps

- Problem-solving tasks besides Context-rich problems need investigation
  - Jeopardy and WRONG
- Appropriate tasks outside Physics
- Transfer
  - Skills, knowledge, resources, etc.