Learning Physics Through Problem Solving at the University of Minnesota

Course Structure

LECTURES

Three hours each week, sometimes with informal cooperative groups. **Model** constructing knowledge, **model** problem solving framework.

RECITATION SECTION

One hour each Thursday – cooperative groups practice using problem-solving framework to solve context-rich problems. **Peer coaching, TA coaching.**

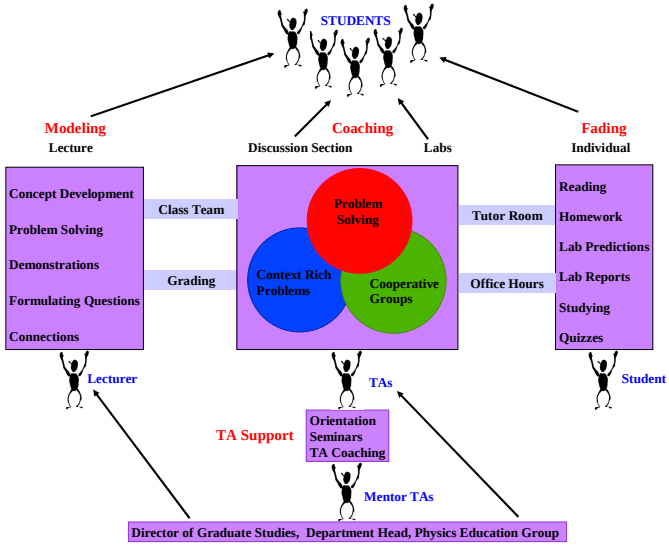
LABORATORY

Two hours each week -- ***same*** groups practice using framework to solve concrete experimental problems. ***Same*** **TA. Peer coaching, TA coaching.**

TESTS

Thursday– group problem-solving quiz.

Friday -- individual problem-solving quiz & conceptual questions (usually multiple choice) every three weeks.



A Problem Solving Framework

(adapted from Polya 1957)

STEP #1 — Recognize the Problem: What's going on?

STEP #2 — Describe the problem in terms of physics: What does this have to do with physics ?

STEP #3 — Plan a solution: Can I use what I know to get an answer?

STEP #4 — Execute the plan: Get an answer

STEP #5 — Evaluate the solution: Can this be true?

Context Rich Problems

- Each problem is a meaningful situation in which the major character is the student. The problem statement uses the personal pronoun **"you"**.
- **Decisions** are necessary to proceed.
- The problem statement includes a plausible **motivation** or reason to calculate something.
- The **objects** in the problems are **real** (or can be imagined) -- the student provides the idealization.
- **No pictures** or diagrams are given with the problems. Students must visualize the situation by using their own experiences.
- The problem can **not** be solved in **one step** by plugging numbers into a formula.

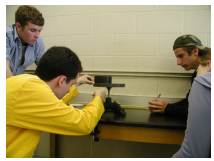
Discussion Section (50 minutes)

1. A context-rich problem is distributed
   - Topic previously modeled in lecture
   - 1 problem per session
2. Students work in groups to solve problem
   - Groups of 3 or 4 assigned by TA
   - 5 groups per section
   - Cooperative group structure
   - Groups change after each quiz (~3 weeks)
   - No books or notes allowed
3. TA coaches each group
   - TA observes groups working on problem
   - TA decides which group to coach
   - Each coaching intervention less than 5 minutes
4. TA assigns a representative of each group to put a section of their solution on the board.
5. TA leads a short (~ 10 minute) discussion focused on work on the board
6. TA collects problems and hands out complete solution to each student.
   - Only 1 solution per group
   - Problem solutions are graded only for group part of quiz (~every 3 weeks)

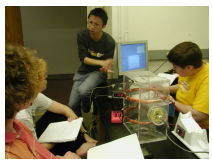
Laboratory Section (2 hours)

1. To attend each week's laboratory
   - Student must pass a web quiz on assigned text reading
   - Student must turn in their best try at solving the assigned lab problems and warm-up questions.
   - Usually 2 laboratory problems (context-rich) assigned per session
2. Each group discusses individual predictions and arrives at a group prediction for each problem
   - Same group as in discussion section
   - Cooperative group structure
3. TA assigns a representative of each group to put the prediction of one problem on board.
4. TA leads a short (~ 15 minute) discussion
   - Compare and contrast predictions
   - What is the physics behind each prediction
   - What assumptions have been made
   - Correct answer is not given
5. Students use equipment to test their predictions
   - Lab manuals are allowed
   - Text books are allowed
   - Notes are allowed
6. TA coaches each group
   - TA observes groups working on problem
   - TA decides which group to coach
   - Each coaching intervention less than 5 minutes
7. TA assigns a representative of each group to put a section of their results on the board.
8. TA leads a short (~ 10 minute) discussion focused on work on the board
9. At the end of a topic (~3 weeks) TA assigns each student to hand in a lab report.
   - Each student in a group reports on a different problem
   - Reports are short (~4 pages) technical memos.

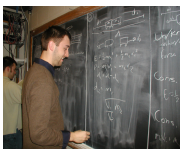
Groups discuss physics and reality
TA coaches a group in the background.



Group prepares to take data



TA coaching a group



Group representative putting part of group's solution on board

Lab Group analyzing Data

Examples of Context-Rich Problems

1. You have been hired as a technical advisor for the police to help in the scientific investigation of crimes. A shooting happened in an apartment but the people in a neighboring apartment claim that they did not hear a shot. You have been assigned to use the physical evidence to determine if they are telling the truth. You know that if the bullet travels faster than the speed of sound, 330 m/s, most of the noise comes from the sonic boom that no silencer can eliminate. You search the crime scene in the apartment and find that a bullet went through a cookbook and then entered the wall. From the dust patterns on a table, the book was sitting on the edge of the table when the bullet ripped through its center knocking it to the floor. From the entrance and exit hole in the book, the bullet was going horizontally as it passed through it. When you find the bullet hole in the wall, you measure that the bullet dropped by 5.0 mm since passing through the book. You dig the bullet out of the wall and measure its mass as 2.4 grams. You also measure the height of the table above the floor, 1.5 m, the distance of the book on the floor from the table, 0.30 m, the distance from the wall to the table, 5.0 m, and the mass of the book, 1.1 kg. The police want you to tell them the speed of the bullet so that they can tell whether the neighbors are telling the truth.

2. You are helping a friend design a pendulum clock for a class project. The timing mechanism for the clock is a 0.75 m long metal bar pivoted at its end. The period of the pendulum is adjusted by means of a small lead ball attached to the bar so that it can be moved. The mass of the ball is the same as the mass of the bar. Your friend has asked you to determine the position of the ball along the bar that will give a period of 2.0 seconds when the bar swings.

Characteristics of Cooperative Groups

- Positive Interdependence
- Face-to-Face Interaction
- Individual Accountability
- Explicit Collaborative Skills
- Group Functioning Assessment

Details available at
http://groups.physics.umn.edu/physed/

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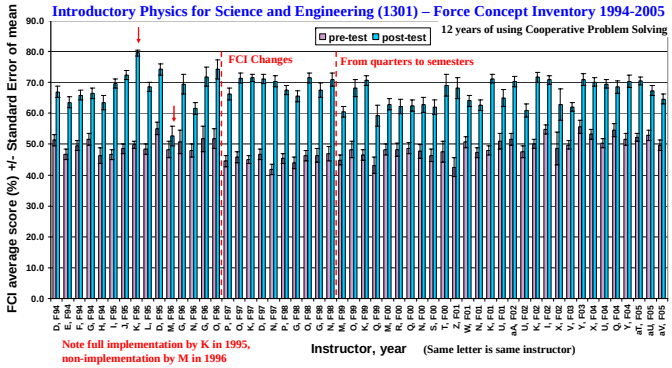
Introductory Physics for Science and Engineering (1301) – Force Concept Inventory 1994-2005



Note full implementation by K in 1995, non-implementation by M in 1996

Instructor, year (Same letter is same instructor)

Introductory Physics for Science and Engineering