

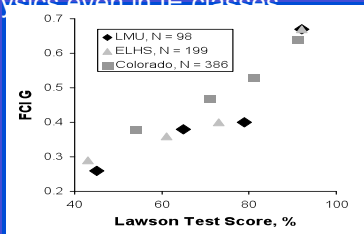
Developing Thinking & Problem Solving Skills in Introductory Mechanics

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BACKGROUND

Students with weak reasoning skills are likely to have limited success learning physics even in IE classes.



Students' conceptual learning in IE physics classes, as measured by FCI G, is strongly correlated with their preinstruction reasoning skills, as measured by Lawson's Test. The graph shows student data from Loyola Marymount, U. of Colorado, & Edward Little HS, with individual student data grouped into quartiles of Lawson scores.

Thinking in Physics (TIP)

The Thinking in Physics program addresses many facets of student performance, including impulsiveness & attention to detail, metacognition, control of variables & kinds of variable relationships, and strategic thinking about problem solving, using a variety of lab and classroom activities.

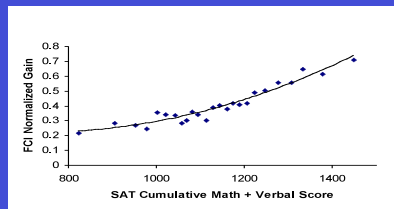
DEVELOPING SCIENTIFIC REASONING

TIP often uses the context of physics to teach thinking about variables.

An experiment in the physics of fluids: Masses can be placed in a model plastic boat floating in a fish tank. Students are asked to identify pertinent variables and their relationship. They are then asked to determine how the pressure depends on the depth of the boat in the water. In all activities, the kind of variable relationship is highlighted along with the physics concepts.

TIP RESULTS Scientific Reasoning

TIP was integrated into 4 sections of introductory mechanics taught from 2007 to 2009 and into a pre-physics Thinking in Science course, designed to prepare at risk students for introductory mechanics, using TIP methods. In all five of these TIP classes, the Lawson Test was administered both pre and post instruction. Lawson Test scores, averaged over all five TIP classes, improved from 69% preinstruction to 78% postinstruction, which corresponds to an average normalized Lawson gain of 0.29. The average normalized gains of the five classes varied significantly (0.40, 0.38, 0.26, 0.20, and 0.15), and individual students' normalized gains varied widely: standard deviations of Lawson gains in the five sections ranged between 0.3 and 0.5.

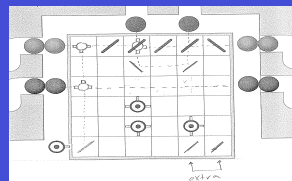


Combined, binned data from LMU and ELHS (N = 627) indicates a strong correlation between SAT scores and FCI G.

Can we strengthen students' reasoning skills & create stronger learning than in typical IE classes?

DEVELOPING PROBLEM SOLVING SKILLS

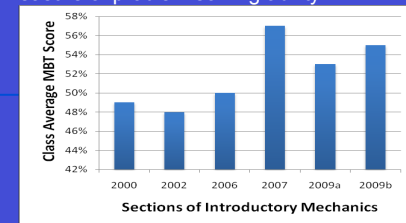
TIP develops students' problem solving skills by developing general thinking skills, by providing a solid physics conceptual base, by modeling effective problem solving strategies, and by encouraging metacognition regarding problem solving. TIP encourages students to use the four step method of problem solving first proposed by Polya: i) formulate the question; ii) plan a solution; iii) execute the plan; iv) review the solution. The specific implementation of each step depends on the problem. The general approach is emphasized in different contexts, including everyday problem solving, puzzles, and physics problems.



An example of a student solution of a TIP computer game (from the MIND Research Institute). Students must develop strategic thinking, planning multiple steps in solution of a problem.

Problem Solving

The Mechanics Baseline Test (MBT) is a standardized exam sometimes used as a measure of problem solving ability.



One of us administered the MBT, postinstruction, in six of his IE introductory mechanics sections from Fall 2000 to Fall 2009. The first three sections were before the TIP program began, and the last three were TIP classes. Because the instructor was the same and the classes were similar in composition, the MBT scores in these classes provides a measure of the impact that TIP has had on students' problem solving ability. In addition to the TIP methods common to all TIP classes, these three TIP sections had special tutorial sessions for at-risk students, meeting in groups of 3 or 4. In 2007 these tutorials sections were guided by the instructor; In 2009 they guided by undergraduate TAs.