How effective is modeling instruction?

In comparison to traditional instruction, under expert modeling instruction high school students average more than two standard deviations higher on a standard instrument for assessing conceptual understanding of physics.

The effectiveness of modeling instruction in enhancing student learning of physics is being continuously evaluated with well-established standardized instruments. Chief among these instruments is the Force Concept Inventory (FCI). The FCI assesses the effectiveness of mechanics courses in meeting a minimal teaching performance standard: to teach students to reliably discriminate between the applicability of scientific concepts and naive alternatives in common physical situations. Questions on the FCI were designed to be meaningful to students without formal training in mechanics.

The FCI has consistently shown that students bring into their physics courses a wide array of naive beliefs about the motion of physical objects that are incompatible with Newtonian theory. Figure 1 summarizes data from a nationwide sample of 7500 high school physics students involved in the Modeling Workshop Project. The average FCI pretest score is about 26%, slightly above the random guessing level of 20%, and well below the 60% score which, for empirical reasons, can be regarded as the threshold for understanding Newtonian mechanics.

Figure 1 shows that traditional high school instruction (lecture, demonstration, and standard laboratory activities) has little impact on student beliefs, with an average FCI posttest score of about 42%, still much below the Newtonian threshold\(^1\). This failure of traditional instruction is largely independent of the instructor’s knowledge, experience and teaching style.

High school teachers in the Modeling Workshop Project begin a shift from traditional instruction to modeling instruction in their first four-week summer workshop. After their first year of teaching, posttest scores for students of these novice modelers are about 10 percentage points higher, as shown in Fig. 1 for 3394 students of 66 teachers. Students of expert modelers do much better. For 11 teachers identified as expert modelers after two years in the Project, posttest scores of their 647 students averaged 69%. Thus student gains in understanding under expert modeling instruction are more than doubled (40 percentage points gained), compared to traditional instruction (16 percentage points gained) (Figure 1).

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