Measuring development of introductory physics students’ problem-solving skills

Qing Xu¹, Ken Heller¹, Leon Hsu², Andrew Mason², Anne Loyle-Langholz²

¹ School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455
² Department of Postsecondary Teaching and Learning, University of Minnesota, Minneapolis, MN 55455

Goal

Establish a baseline of the evolution of students’ problem solving skills in an introductory physics class. This can be used to assess the impact of instructional changes (such as the use of computer problem-solving coaches).

Sample

• 38 students from one section (total 108 students) of a Spring 2011 calculus-based introductory mechanics class for engineers and physical science majors at the University of Minnesota.
• 2 problems from each of 4 quizzes given at approximately 3-week intervals assessed using a problem-solving rubric.

Results

Qualitative differences between tiers

As can be seen from Fig. 4, the problem solutions of students in Tier 1 earned noticeably higher rubric scores than those of students in Tier 3, even though the grades assigned by the TAs were obtained independently of the rubric scores.

Evolution of problem-solving skills

Fig. 5 shows that there is no evidence of any gain or loss in any of the 5 rubric categories over the course of the semester.

Analysis

• Two experienced assessors independently applied the rubric to the written solutions of 38 students for each problem, then compared and discussed their ratings before moving on to the next problem.
• The agreement between the two raters after discussion was greater than 99%.

Quiz 1 Problem 1

Just as a passenger train that you boarded a few moments before is beginning to pull out of the station, it is passed by a freight train traveling at 60 mi/h along a parallel track in the same direction that your train is headed. If your train undergoes constant acceleration, how far will you have traveled before is beginning to pull out of the station, it is passed by a train’s acceleration is that it takes 3.5 miles for the train to reach a speed of 60 mi/h, starting from rest.

Quiz 4 Problem 1

A 13-kg cube block, 30 cm on a side, is at rest on a level floor. A 400-g glob of putty is thrown at the block perpendicular to one face of the block so that the putty travels horizontally, hits the block in the center of the face, and sticks to it. The block and putty slide 15 cm along the floor. If the coefficient of kinetic friction is 0.40, what is the initial speed of the putty?

Summary

• The problem solving rubric distinguishes between students who perform at different levels in solving problems.
• The scores achieved by students remain constant as a function of time across all categories.
• Future work includes measuring a baseline in the second (E&M) semester, in mechanics courses taught in the fall, and measuring the impact of students’ use of computer problem-solving coaches.

References


For further information

Visit our website: http://groups.physics.umn.edu/physed/

This work was supported by the National Science Foundation under DUE-0715615.