Exploring Instructor Knowledge of Student Ideas using the Force Concept Inventory

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Abstract

Pedagogical content knowledge has been a useful construct for conceptualizing the knowledge-base that supports reform teaching practices. In physics education, we are still far from having established methods and instruments for assessing such knowledge. In an attempt to begin exploring possibilities for assessing instructor knowledge of student thinking, we asked a small sample of college physics instructors to take the Force Concept Inventory in two novel ways. Instructors were first asked to indicate the answer that they think a typical novice student would choose prior to instruction and then to estimate the fraction of students answering correctly after instruction. We analyze how instructor responses compare with actual student data and discuss questions with significant mismatch-either ones that instructors overwhelming succeeded (or failed) at identifying student difficulties or questions where instructors were overwhelmingly pessimistic (or optimistic) about student performance.

FCI Adapted as a Tool to Explore PCK

Using the Force Concept Inventory, we asked five university instructors what they thought be the most commonly chosen incorrect answers before instruction, and to anticipate how many students answered correctly after instruction.

- **How well could different instructors identify the incorrect answers their students would pick?**
- **How well could instructors predict which questions would be difficult for students?**
- **Could instructor responses tell us anything about their awareness of student difficulties and their awareness of their prevalence in their course?**

Instructional Context: Algebra-based

The Department of Physics and Astronomy at Middle Tennessee State University (MTSU) utilizes many reforms in their introductory algebra-based physics sequence.

Algebra-based Physics in Studio-like Environment

Various Interactive Engagement Methods

Diversity of Majors, General Education

Small Student Instructor Ratio (32:1)

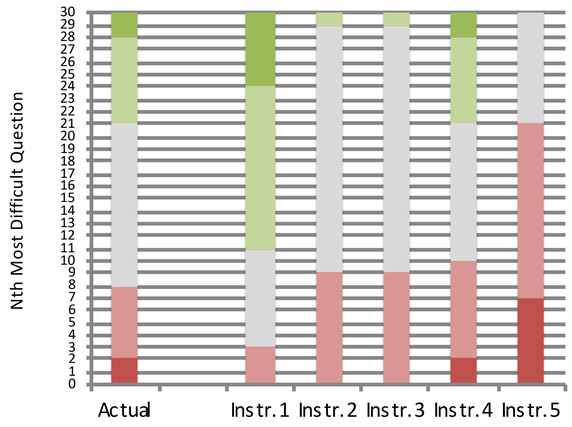
Physics Majors serve as Undergraduate TAs

5 Hours per Week in Workshop Setting
- Collaborative Problem-solving
- Interactive Demonstrations
- Laboratory Investigations

1.5 Hours per Week of Lecture
- Peer Instruction

Traditional Introductory Physics Topics

Instructor Accuracy in Predicting Student Success



Question difficulties with 30 representing the easiest question for and 1 representing the hardest. Instructors toward the left were optimistic compared to actual student performance, while instructors toward right were pessimistic..

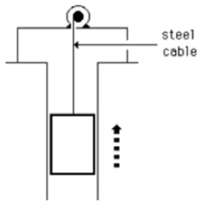
Pessimistic about N3rd Law Collision

4. A large truck collides head-on with a small compact car. During the collision:
(A) the truck exerts a greater amount of force on the car than the car exerts on the truck.
(B) the car exerts a greater amount of force on the truck than the truck exerts on the car.
(C) neither exerts a force on the other, the car gets smashed simply because it gets in the way of the truck.
(D) the truck exerts a force on the car but the car does not exert a force on the truck.
(E) the truck exerts the same amount of force on the car as the car exerts on the truck.

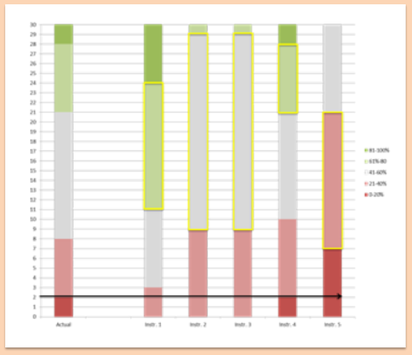
Questions where instructors were overly pessimistic about student performance were often questions with canonical situations with easily memorizable answers.

Over-Optimism about Force Comparisons for Constant Velocity

An elevator is being lifted up an elevator shaft at a constant speed by a steel cable as shown in the figure below. All frictional effects are negligible. In this situation, forces on the elevator are such that:
(A) the upward force by the cable is greater than the downward force of gravity.
(B) the upward force by the cable is equal to the downward force of gravity.
(C) the upward force by the cable is smaller than the downward force of gravity.
(D) the upward force by the cable is greater than the sum of the downward force of gravity and a downward force due to the air.
(E) none of the above. (The elevator goes up because the cable is being shortened, not because an upward force is exerted on the elevator by the cable).

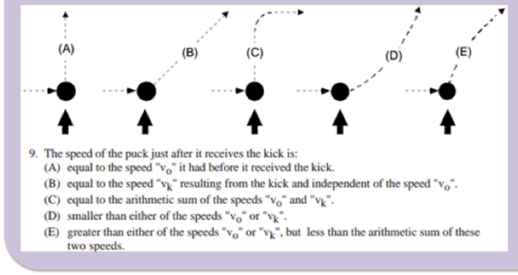


Elevator going up at constant speed

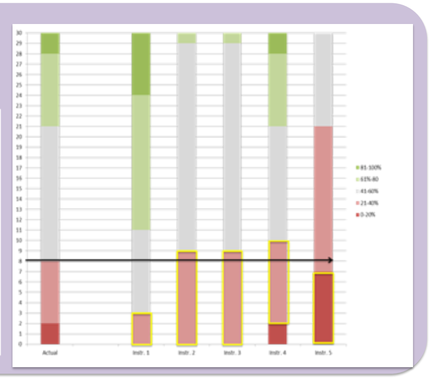


2nd Most Difficult Question was Ranked Much Easier by Instructors

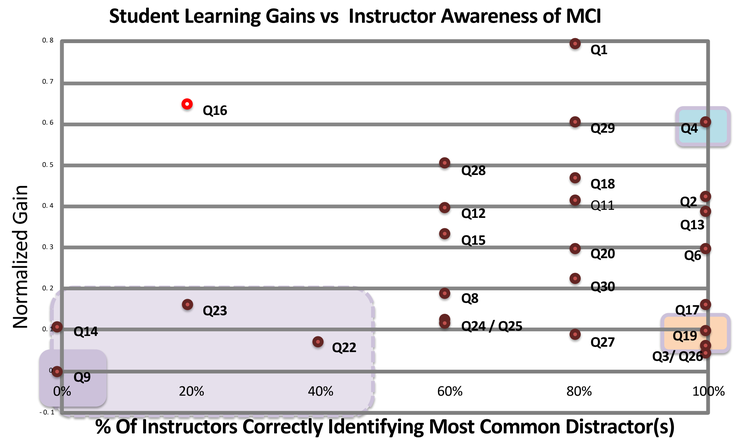
Accurate Estimate of Difficulty



9. The speed of the puck just after it receives the kick is:
(A) equal to the speed "v_O" it had before it received the kick.
(B) equal to the speed "v_K" resulting from the kick and independent of the speed "v_O".
(C) equal to the arithmetic sum of the speeds "v_O" and "v_K".
(D) smaller than either of the speeds "v_O" or "v_K".
(E) greater than either of the speeds "v_O" or "v_K", but less than the arithmetic sum of these two speeds.



Student Learning and Instructor Awareness



Questions where instructors could not collectively identify the MCI answers had low gains, except for Q16 which likely has high normalized gains due to false positives.

Professors being over-optimisitic about student performance could mean either that they are unaware of poorly students grasp the content laid out in curriculum or might not be fully aware that a certain misconception is as difficult as they had previously thought. this can be seen by the low student performance on questions where professors were both absolutely and relatively over-optimistic.

Low instructor-awarness of the most common incorrect answers might also serve as an indicator for poor student performance. It is found that all of the questions that less than 60% of professors could accurately identify the MCI had low normalized gains.

Concluding Remarks

Our future efforts will involve broadening the use of the FCI as preliminary tool as to include a broader range of instructors, both in terms of their experience and instructional settings, with continued efforts to examine potential correlations between instructor knowledge and student learning. This ongoing preliminary work is being used to inform the development of interviews and potential survey items that meaningfully probe at instructor's knowledge of student thinking about force and motion.

References

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