Mar 9th, 1:45 PM - 2:00 PM

A Medley of Successful Active-Learning Methods

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A Medley of Successful Active-Learning Methods in Introductory and Upper-Level Physics Courses

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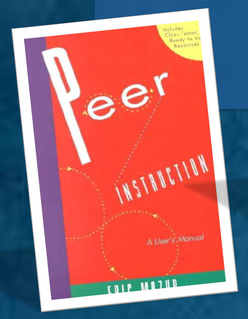
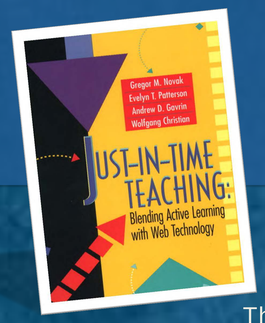




This workshop will present a medley of active-learning methods that have been implemented successfully in both introductory and upper-level physics courses. The participants will engage in methods that include Just-in-Time Teaching (JiTT), clicker questions, whiteboard activities, and virtual experiments. The workshop will be designed very much like a class that employs these methods, with a pre-workshop online assignment that is due "Just in Time" before the workshop, and whiteboard activities and clicker questions associated with the active-learning methods. The participants will work in teams to develop some JiTT assignments, clicker questions, and whiteboard activities that they could use in their own classes. The goal of the workshop is to allow the participants to experience this combination of active-learning methods and appreciate how the methods can be combined and applied in a STEM classroom to increase students' conceptual understanding and problem solving skills.

Just-in-Time Teaching is a pedagogical strategy that employs the Internet to develop and utilize a feedback loop between students and instructors that exists both in class and out of class. The JiTT method involves a three-step process:

(1) a pre-instruction reading assignment with concept-based questions (*ie*: the WarmUp exercise),
(2) an in-class discussion of the conceptual questions, and
(3) a group activity involving the concepts discussed in the reading and lecture.

Students are required to answer the pre-instruction WarmUp questions and submit their responses via the Internet a few hours before lecture begins. The instructor reviews the student responses to the questions and designs the lecture structure and activities according to the students' (mis)understanding of the concepts.

The JiTT method encourages critical thinking and reflective writing – even before coming to class!

Peer Instruction is an interactive teaching method that is most effective when used with Just-in-Time Teaching. Steps (2) and (3) of the JiTT process are accomplished through conceptual questions ("clicker questions") that address students' misunderstandings. The "Peer" instruction comes in when the students think about their answers to the questions. They discuss their thoughts and ideas with their peers and together agree on an answer.

Peer Instruction encourages critical thinking, complex problem solving, teamwork, quantitative reasoning and creativity – in the classroom, where the instructor can give instant feedback!

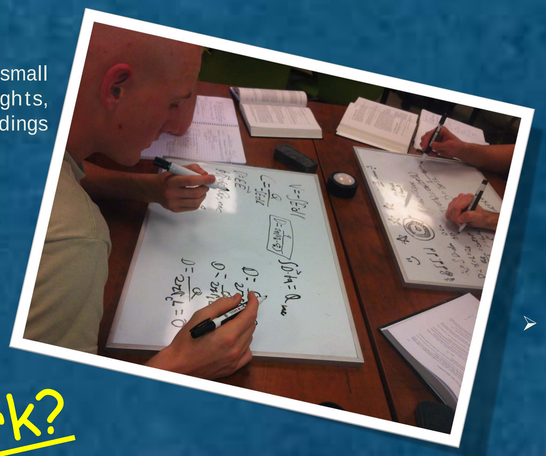
In my Active-Learning Classroom

Students come to class with some familiarity with the material to be covered that day. They may not be experts, but they will at least recognize the concepts and they will have already thought about some of the problems to be solved that day.

Teams of four students are assigned (and then re-assigned in about four weeks) and these teams work together to solve the in-class problems.

The classroom is enabled with technology to enhance active-learning methods. There are tables rather than individual desks to promote teamwork and peer instruction. Interactive whiteboards are on all four walls of the room, making every seat a good seat. Laptop computers are available for simulated experiments and computational calculations. Individual whiteboards are used by the teammates to solve in-class problems and then present their solutions to the class.

Students work together on problems in class, showing their work on small whiteboards. This allows the teammates to discuss their solutions, thoughts, ideas, and also allows the instructor to realize the students' (mis)understandings instantly and provide immediate feedback.



A team who believes they have come up with the correct solution may "buzz in" with an electronic buzzer. That team presents their solution to the class and the team is awarded extra-credit points for correct solutions.

Examples of some JiTT WarmUp questions for PHYS 2211:

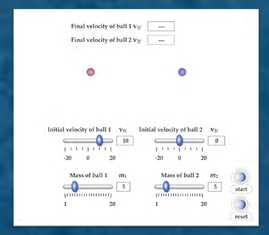
- Lesson on Newton's 1st Law
  - ✧ An object in motion stays in motion, and an object at rest stays at rest, unless acted upon by an outside force.
- WarmUp Question
  - ✧ Explain the need for automobile seatbelts in terms of Newton's 1st Law.

- Lesson on Momentum Conservation
  - ✧ In a system where the net force is zero, linear momentum of the system is conserved (does not change) in a collision or explosion.
- WarmUp Question
  - ✧ You are stranded at the center of a frozen lake (don't ask me how you got there). You can't walk off the lake because there is no static friction between your feet and the ice. When you try to slide to the shore, you remain in the same spot - again due to the lack of static friction. Fortunately, you are carrying your physics textbook. Explain how you can get off the lake and to the shore.

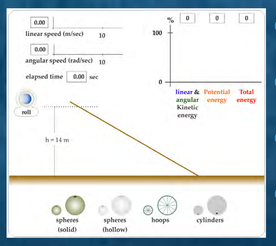
Examples of conceptual Peer Instruction questions for PHYS 2211:

- Try your intuition on the following question and then test your answer by running the animation. If the two masses are equal, and ball 2 is initially at rest, upon collision:

① ball 1 bounces back with the negative of its initial velocity.
② ball 1 continues with half its initial velocity, and ball 2 also moves off with half the initial velocity of ball 1.
③ ball 1 stops, and ball 2 moves off with the initial velocity of ball 1.
④ ball 1 stops, and ball 2 moves off with twice the initial velocity of ball 1.



- Test the effect of the distribution of mass: Run the animation for the larger solid sphere and the larger hollow sphere, noting the linear speed of each at the bottom of the incline and the ratio of linear to angular kinetic energy



① The solid sphere has the larger linear speed and a larger portion of the original PE went into linear KE.
② The solid sphere has the smaller linear speed and a larger portion of the original PE went into linear KE.
③ The solid sphere has the larger linear speed and a smaller portion of the original PE went into linear KE.
④ The solid sphere has the smaller linear speed and a smaller portion of the original PE went into linear KE.

Does it Work?

	Normalized Gain <g>	Newtonian Entry	Newtonian Mastery	Concept Gain, N3 questions
JiTT (N = 129)	37.6% ± 2.0%	39.5%	8.5%	51%
Non-JiTT (N = 93)	17.9% ± 2.5%	20.4%	6.5%	6.6%

The FCI was used to determine if students' beliefs about Newtonian mechanics were transformed from common sense misconceptions to Newtonian understanding. Since the FCI was designed with this measurement in mind, an improved score on the FCI post-test shows a corresponding improvement in Newtonian thinking.