Do you know what an irrotational flow is?

1. Yes
2. No
Incorporating Best Practices in the Classroom

Active/Self-Directed Learning Panel Session

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Motivation for Change

- Taught various thermal fluid subjects in lecture, homework, small project mode at Texas A&M and MIT

- Student evaluations of teaching were always high

- MIT AeroAstro, led by Ed Crawley, was considering significant changes to academic programs and pedagogy

- Luminaries such as Felder, Mazur, Sheppard, Smith, etc gave talks at departmentally-sponsored seminar series
Course Overview (MIT 16.100)

- Disciplinary subject in aerodynamics
- Enrollment typically around 40 students (juniors and seniors)
- Students will have previous fluid dynamics in sophomore year
- Not quite a required course but 2/3’s of students take it

- Course topics include:
  - Incompressible, subsonic, transonic, and supersonic flows
  - Viscous flows with an emphasis on boundary layers
  - Wind tunnel testing and computational methods
16.100 Pedagogy: Then

Then (pre-1999):

- Traditional lectures
- Weekly homework assignments after lectures on material
- Written exams
- Short (two week) team-based design project

Highly-rated instructors + Smart students = Students can apply, analyze, evaluate concepts
Poor student performance on this exam that required application of concepts beyond previous experience and synthesis of concepts on complex problems.
16.100 Pedagogy: Then and Now

Then (pre-1999):

- Traditional lectures
- Weekly homework assignments after lectures on material
- Written exams
- Short (two week) team-based design project

Now:

- Concept questions & mini-lectures in most class periods
- Look-ahead (graded) homework assignments
- Written take-home exams followed up with oral exams
- Semester-long, team-based design project
Using Concept Questions

(following Peer Instruction approach of Mazur and heavily influenced by work of Hake, Hestenes, etc)

• Pose concept question
• Ask students to indicate their answers: we currently use handheld electronic response system (iClicker)
• If most students have the correct answer, give a brief explanation, then move on
• Else, clarify concept:
  ▪ have students discuss with neighbors,
  ▪ give mini-lecture on concept and answers
• Take another poll of students’ answers
• A typical class period will include about 2 concept questions
Irrotational Flow Concept Question

Given the following streamlines for a steady, 2-D flow:

Which of these flows is irrotational:

(1) Only (a)
(2) Only (b)
(3) Both (a) & (b)
(4) Neither
(5) Not enough information
Look-ahead Assignments

• **Problem:** to address conceptual understanding in-class, students must begin learning beforehand

• **Solution:** Reading and homework assignments due prior to in-class discussion of material

• Homeworks are at same level as in past years when given after class
Advantages of Look-ahead Assignments

• Leverage existing resources for basics & derivations while permitting faculty to be value-added in classroom

• Classroom interactions can focus on concepts

• Encourage self-directed learning

• Improve feedback time

• Homeworks can be designed to demonstrate typical misconceptions
Importance of Student Preparation for Active Learning

- Effective implementation of concept questions is not trivial and impacts entire pedagogy

- In Fall 2000, we implemented concept questions in-class but look-ahead assignments were too simplistic

- The Fall 2000 experience led directly to the current implementation in which look-ahead assignments were at the same level as previous years post-lecture assignments
Student Evaluations of Pedagogy: Lecture

Lecture more effective with increased hw difficulty
Student Comments

“I was initially opposed to the idea that I had to do reading & homework before we ever covered the subjects. Once I transitioned I realized that it made learning so much easier!!”

“I was skeptical at first of new techniques like [concept questions], hw on material that hasn’t been learned in lecture. In the end, it worked out very well. This has been a course where I really felt like I got my money’s worth.”

“I really like the format of the class, I think it’s actually a very good way to format a course. At first I didn’t like how the homework was really tricky and it always came before we went over the material in lecture, but after a little bit I didn’t mind it.”

“Doing homework before the lectures is good… makes actual learning in lectures possible.”
Comparison of Final Exam Grades

Significant improvement from 1998 to 2003
A Perspective on Effective Pedagogy

- Learning Objectives
- Feedback from Students
- Assessment of Student Learning
- Best Practices