Do you know what an irrotational flow is?

1. **Yes**
2. **No**

2011 NAE Frontiers of Engineering Education
Tuesday, November 15, 2011

Incorporating Best Practices in the Classroom

Active/Self-Directed Learning Panel Session

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MIT AEROASTRO

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)

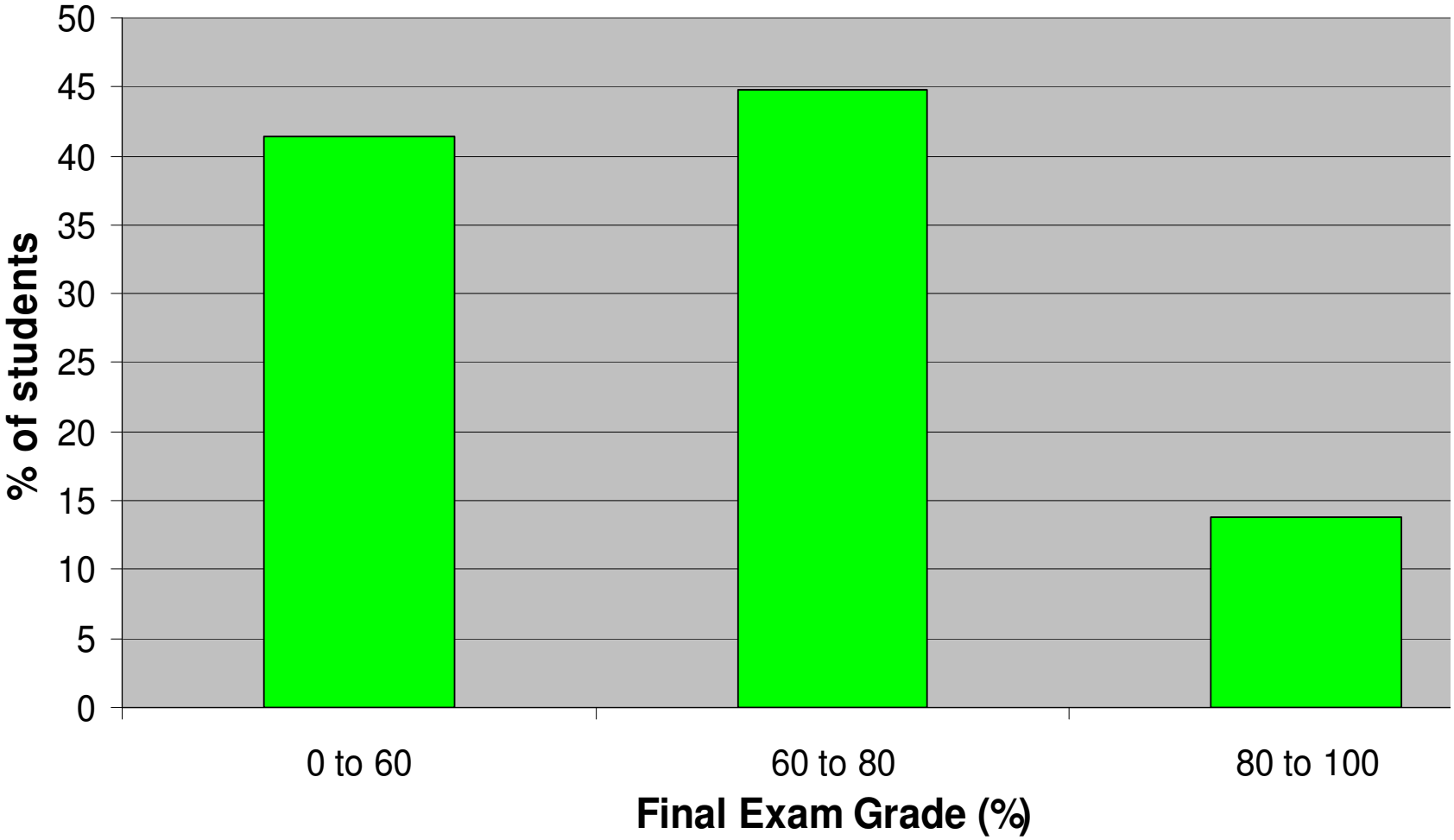
- Disciplinary subject in aerodynamics
- Enrollment typically around 40 students (juniors and seniors)
- Students will have previous fluid dynamics in sophomore year
- Not quite a required course but 2/3's of students take it
- Course topics include:
  - Incompressible, subsonic, transonic, and supersonic 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

Results from 1998 Final Exam



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

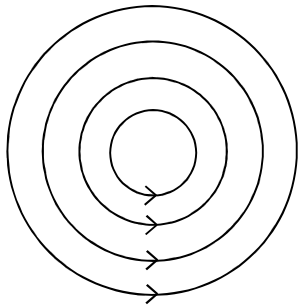
Using Concept Questions

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

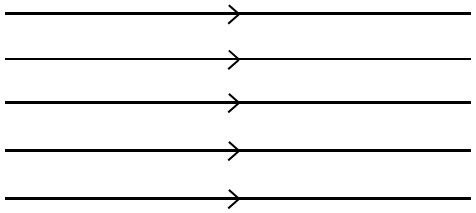
- Pose concept question
- Ask students to indicate their answers: we currently use handheld electronic response system (iClicker)
- If most students have the correct answer, give a brief explanation, then move on
- Else, clarify concept:
  - have students discuss with neighbors,
  - give mini-lecture 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:



(a)



(b)

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

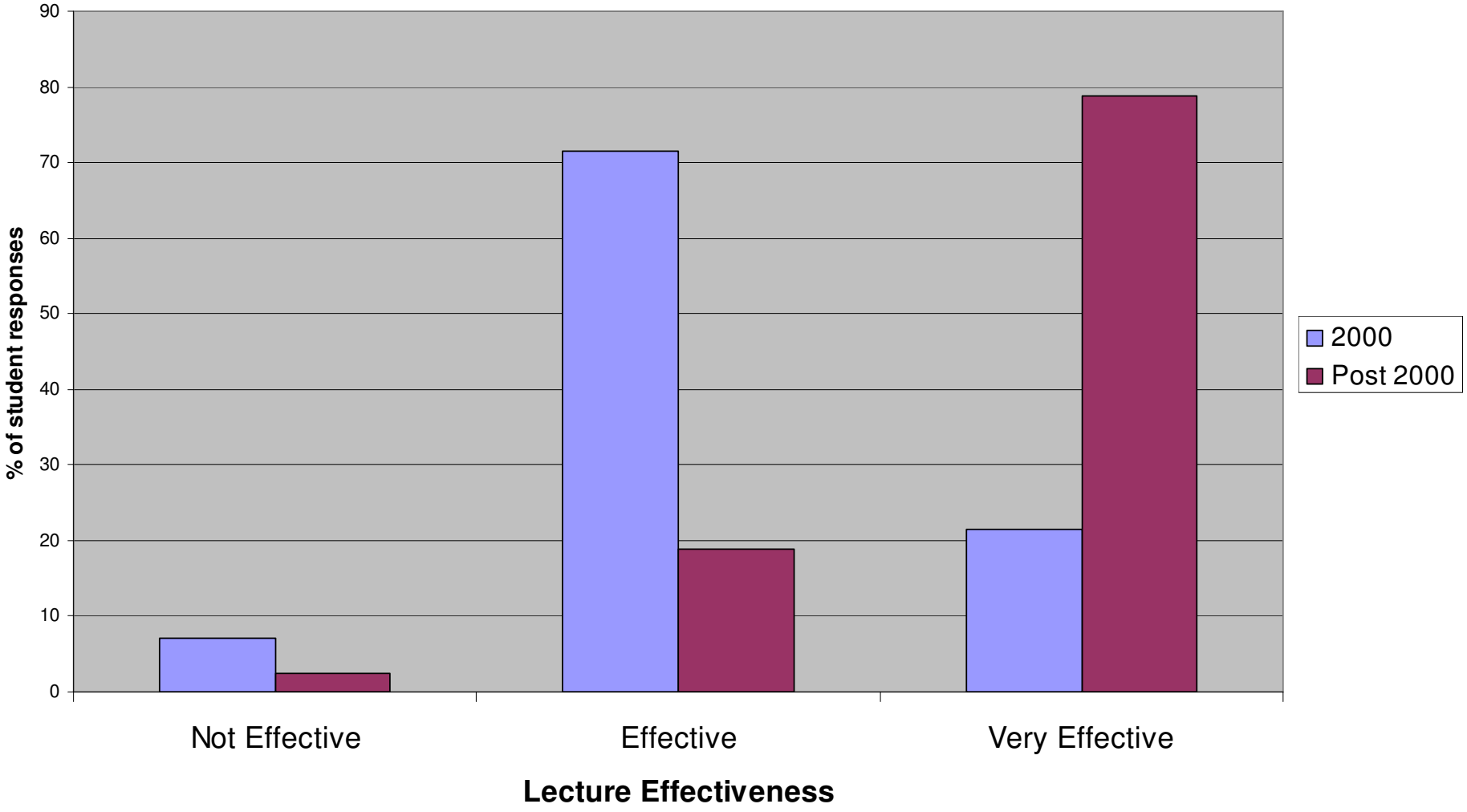
Advantages of Look-ahead Assignments

- 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

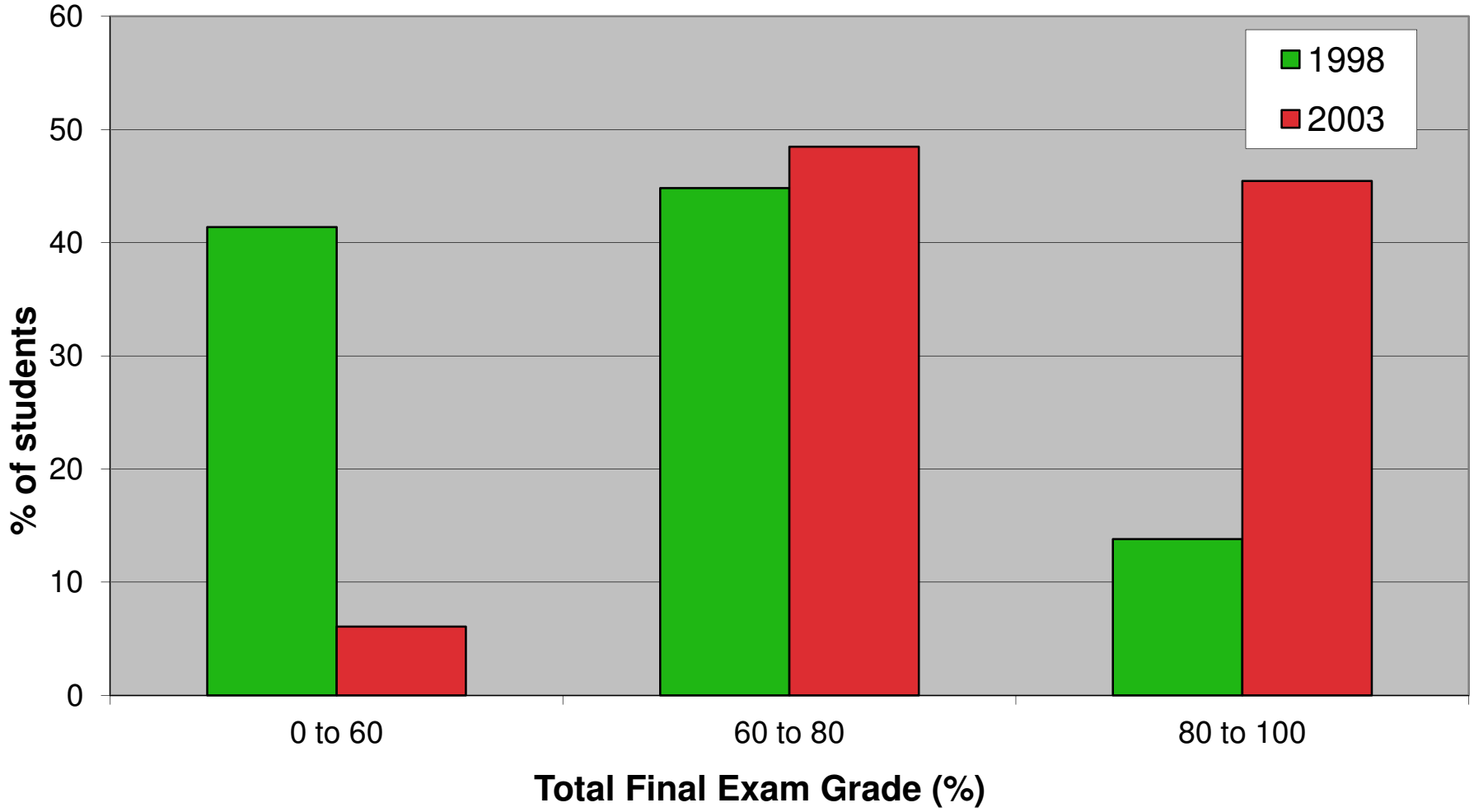
"I was initially opposed to the idea that I had to do reading & homework before we ever covered the subjects. Once I transitioned I realized that it made learning so much easier!!"

"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