



Self-directed Learning: From look-ahead homework to a flexible engineering degree

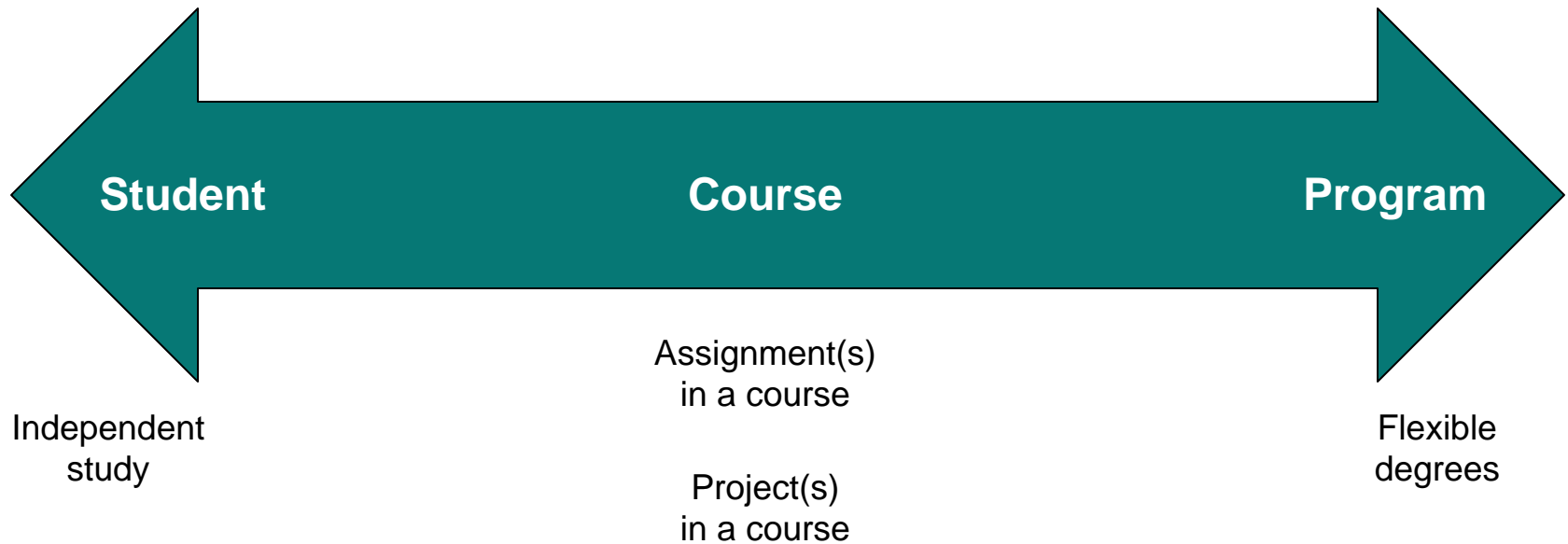
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A Continuum of Self-directed Learning Strategies



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 and Now

Then (pre-1999):

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

Now:

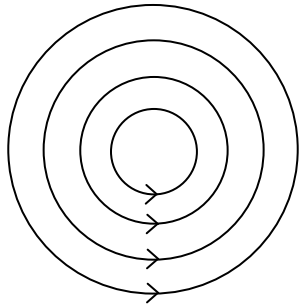
- Concept questions & mini-lectures in most class periods
- Look-ahead (graded) homework assignments
- Written take-home exams followed up with oral exams
- Semester-long, team-based design project

Using Concept Questions

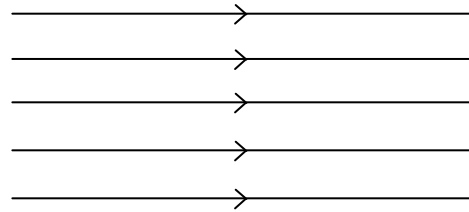
- Pose concept question
- Ask students to indicate their answers: we currently use handheld electronic response system (iClicker)
- If most students have the correct answer, give a brief explanation, then move on
- Else, clarify concept:
 - have students discuss with neighbors,
 - give mini-lecture on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

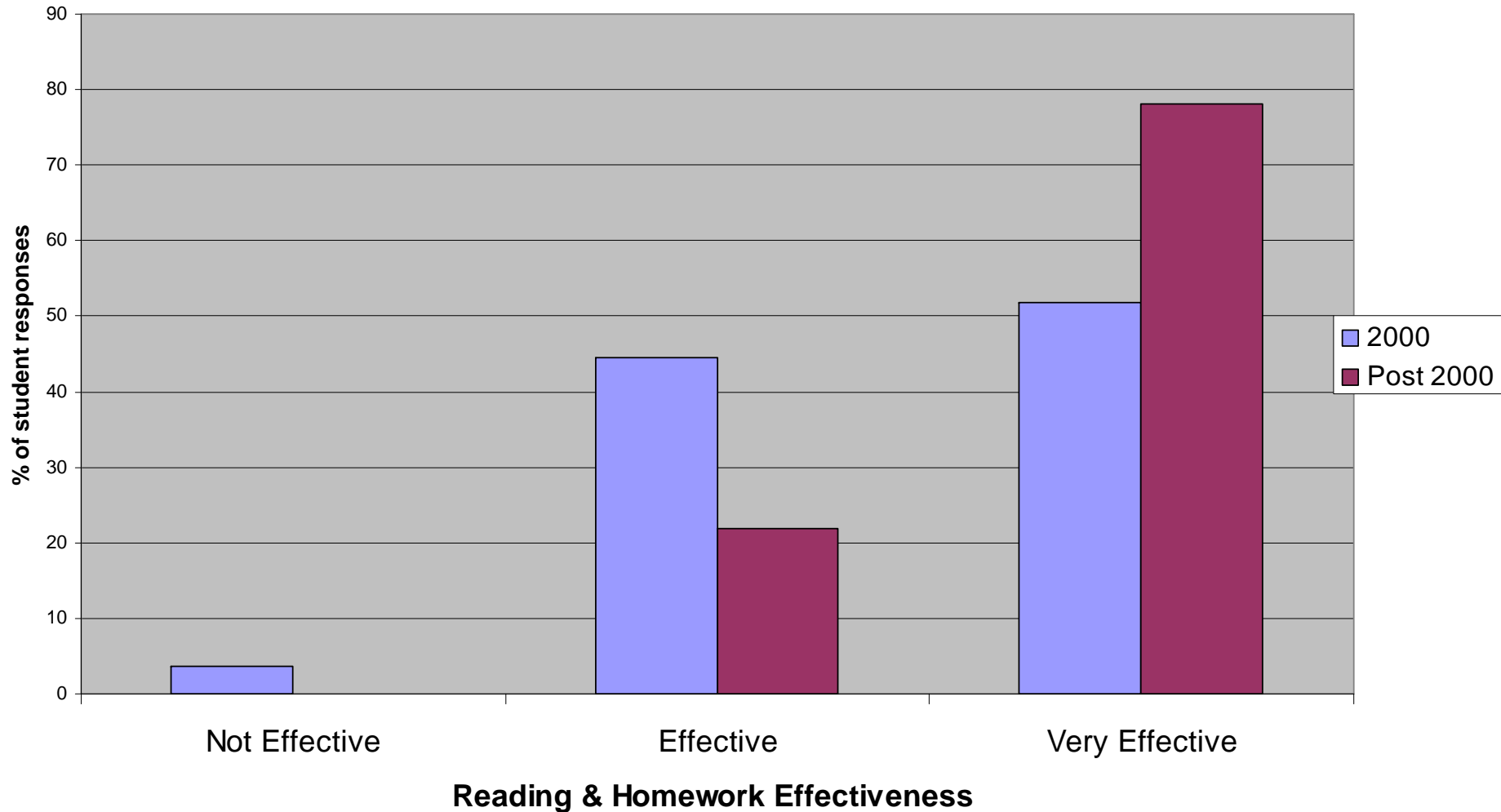
Advantages of Look-ahead Assignments

- 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 Lectures

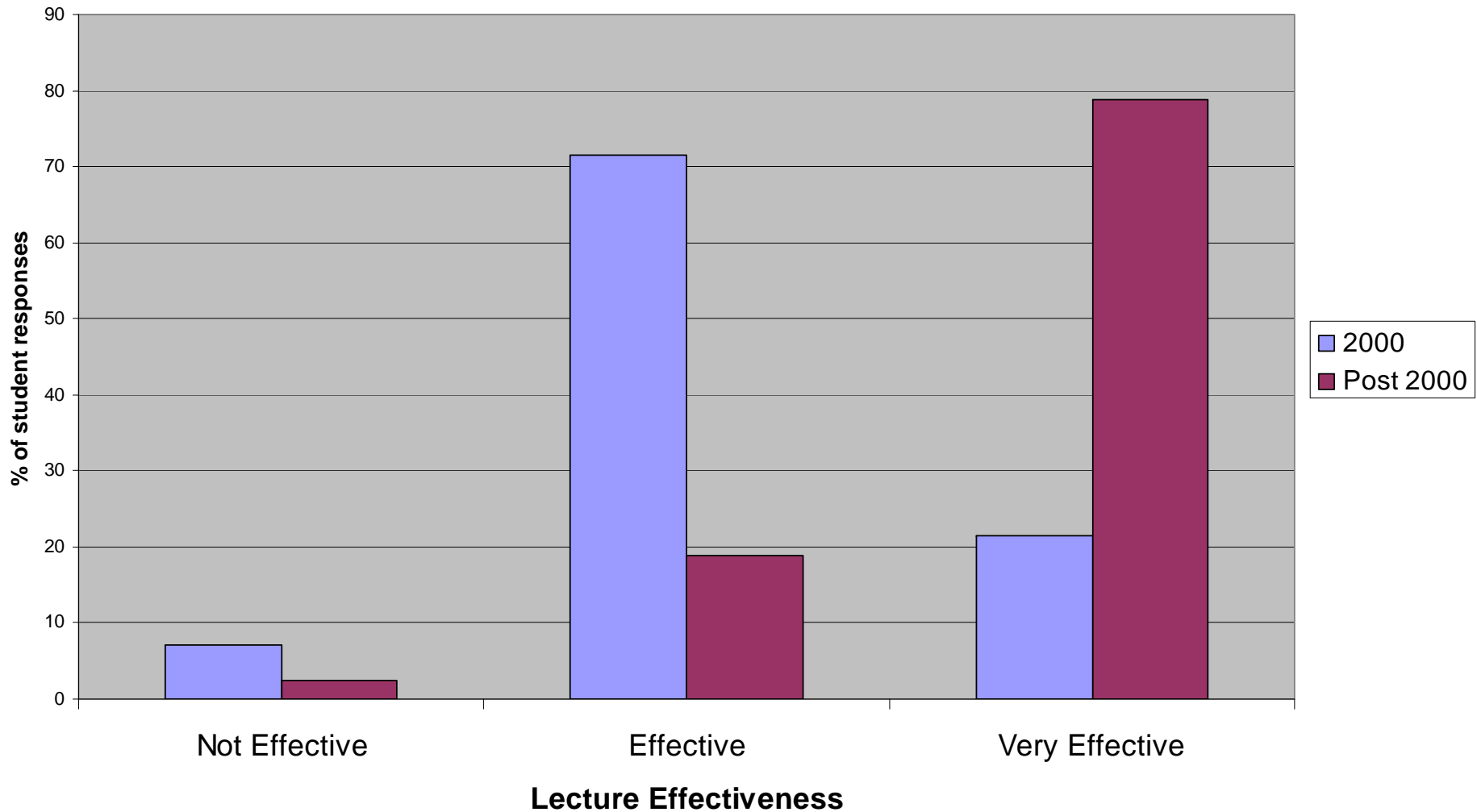
- Effective implementation of concept questions is not trivial and impacts entire pedagogy
- In Fall 2000, we implemented concept questions in-class but look-ahead assignments were too simplistic
- The Fall 2000 experience led directly to the current implementation in which look-ahead assignments were at the same level as previous years post-lecture assignments

Student Evaluations of Pedagogy: Reading & Homework



Reading & hw more effective with increased hw difficulty

Student Evaluations of Pedagogy: Lecture



Lecture more effective with increased hw difficulty

Student Comments:

A Learning Transition Occurred

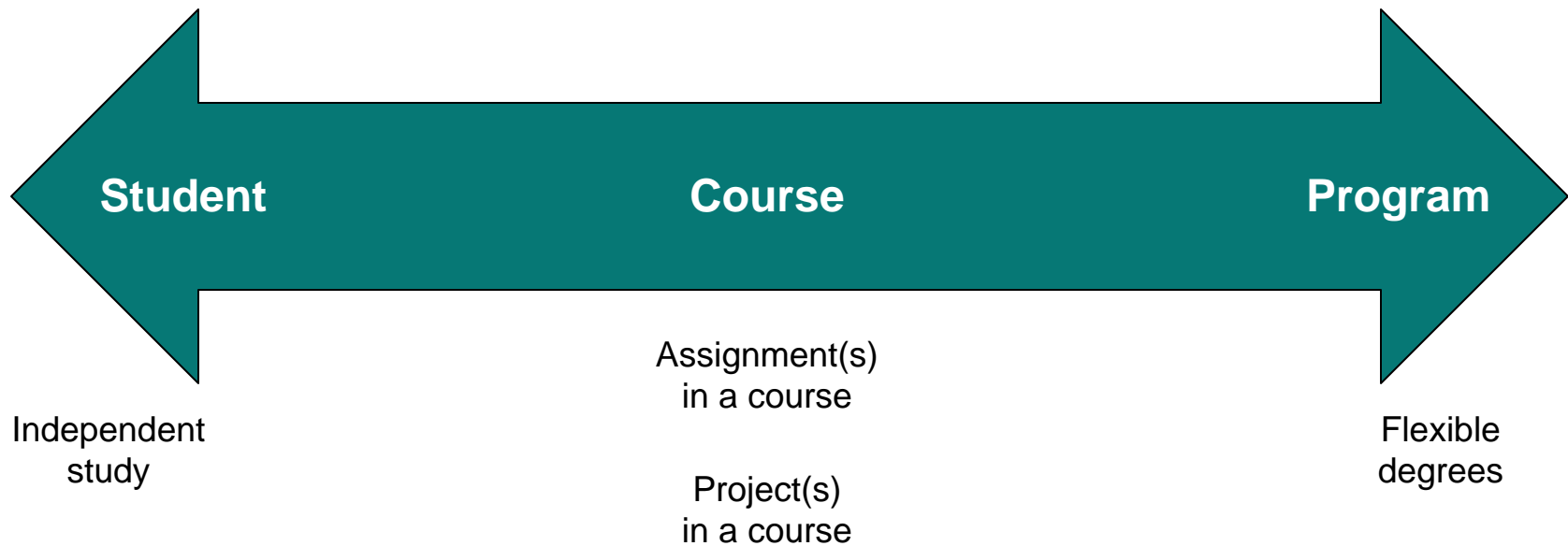
“I was initially opposed to the idea that I had to do reading & homework before we ever covered the subjects. Once I transitioned I realized that it made learning so much easier!!”

“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.”

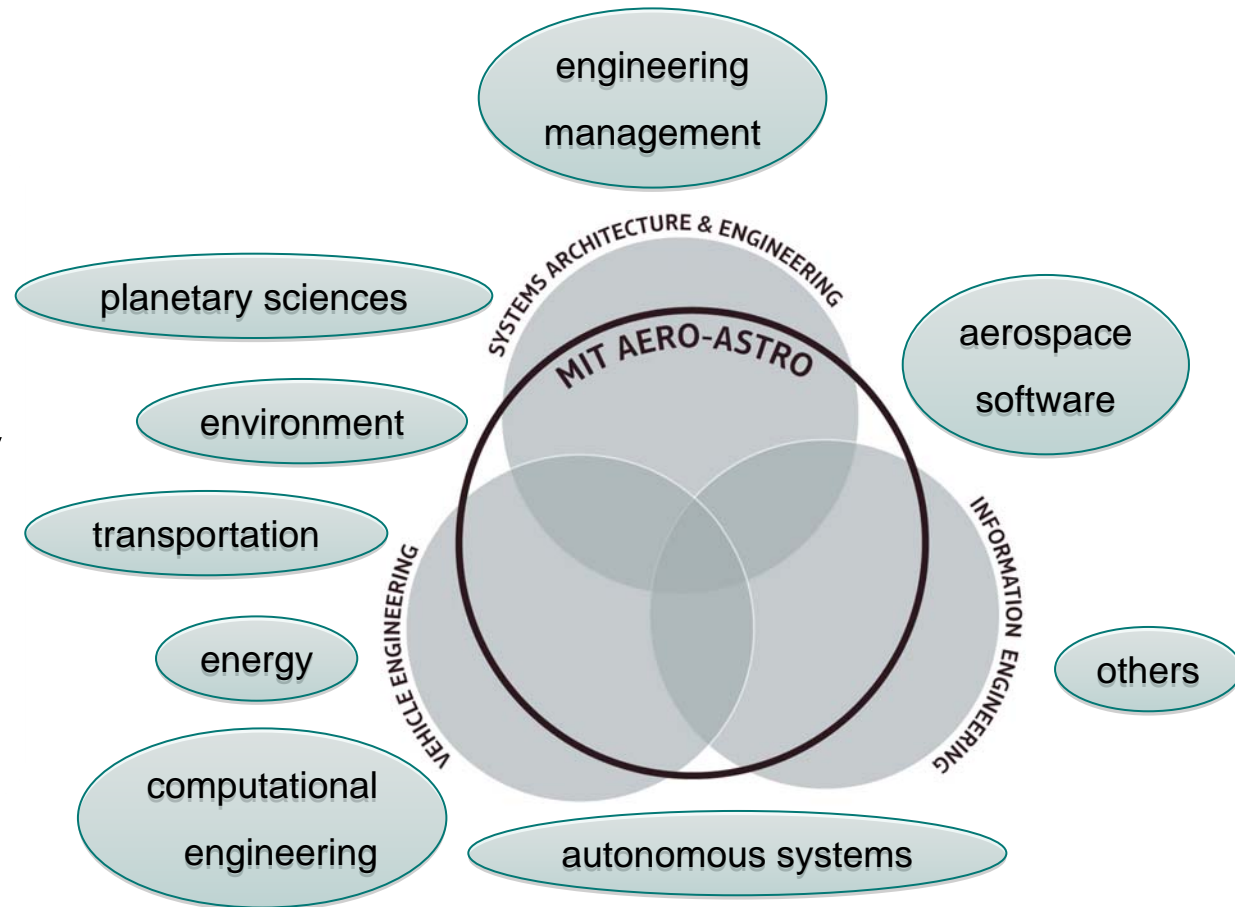
A Continuum of Self-directed Learning Strategies



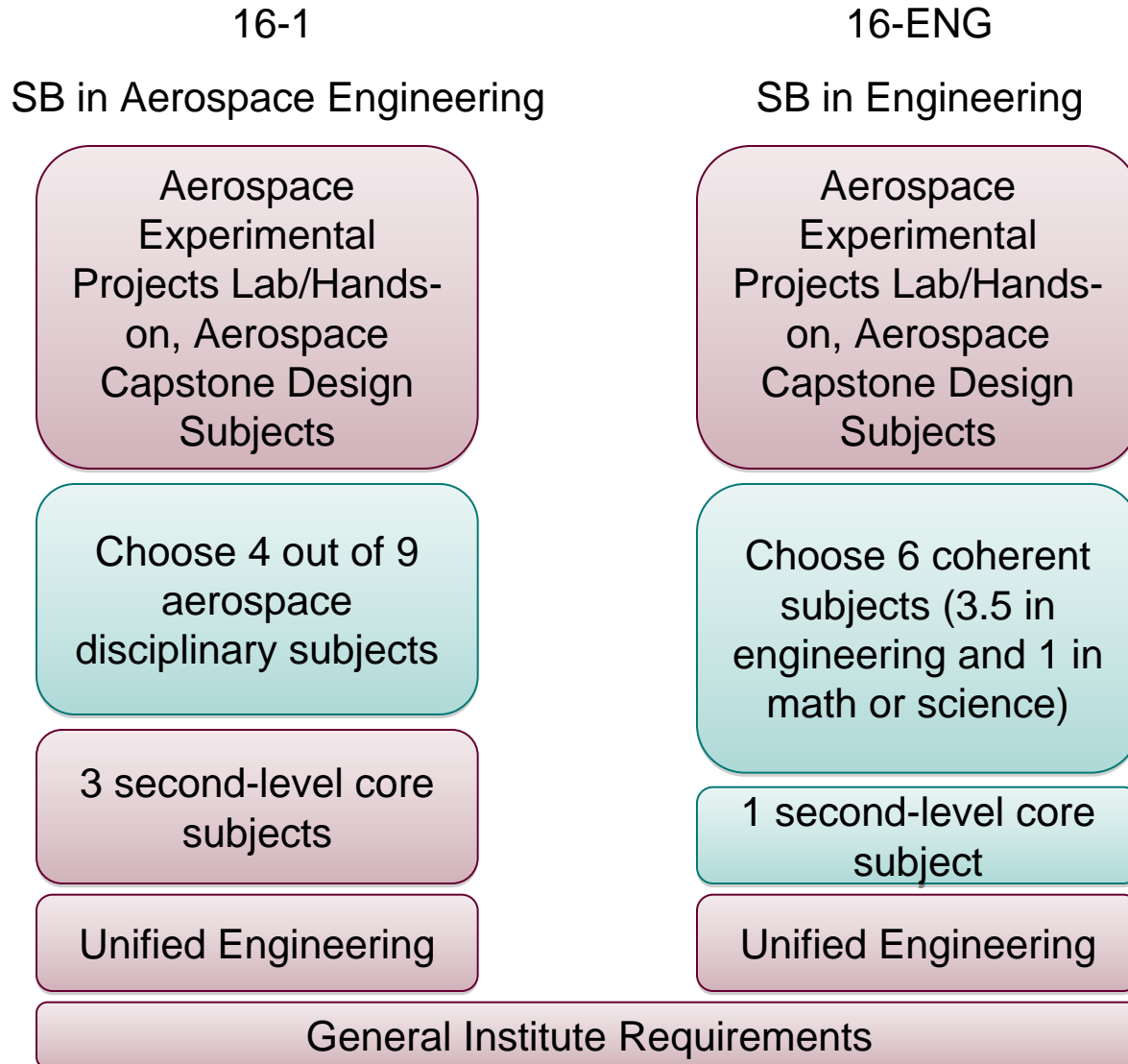
Flexible BS Eng in AeroAstro (16-ENG)

Learning objective:

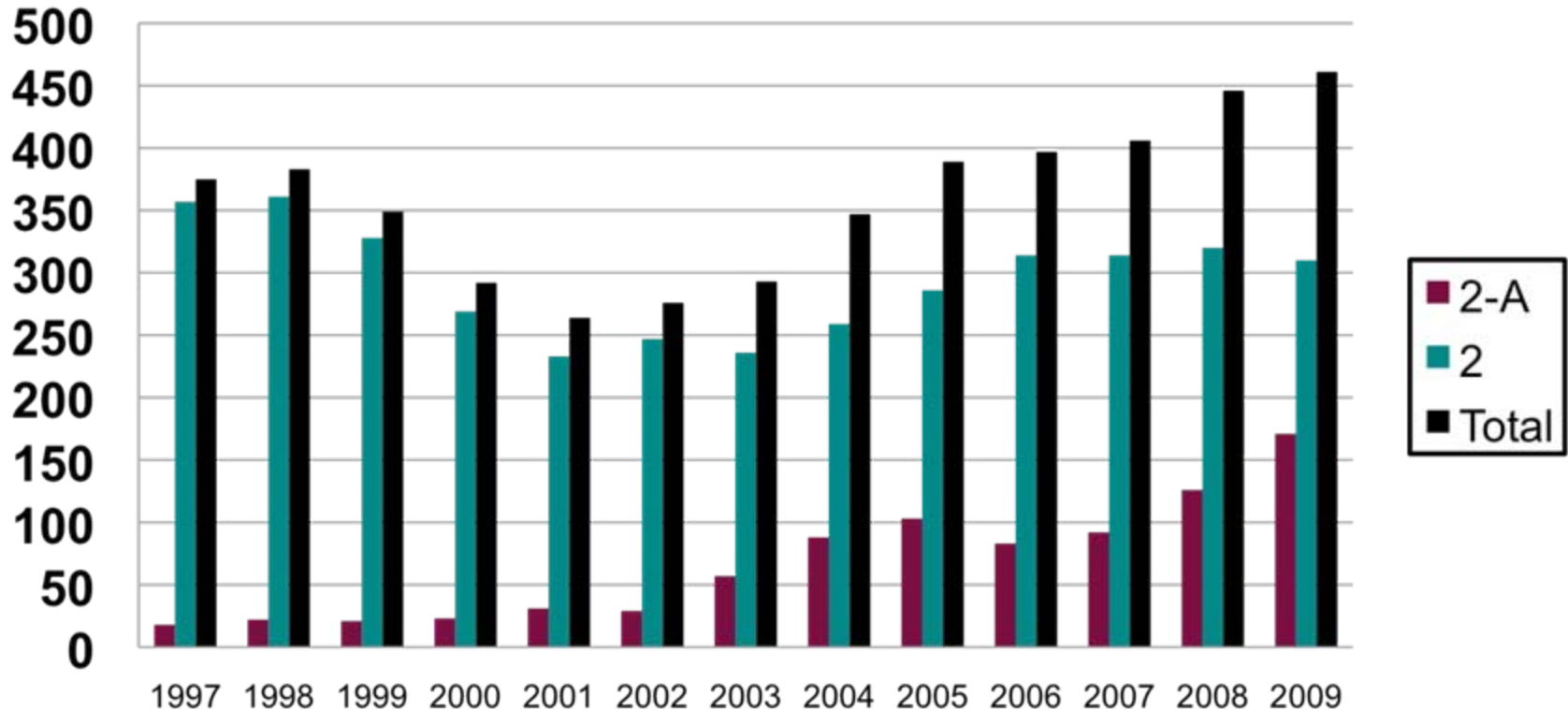
Allow students to gain greater depth of understanding and skill in addressing multidisciplinary and interdisciplinary aerospace engineering problems



Degree comparison



Mechanical Engineering Flexible Degree Enrollment

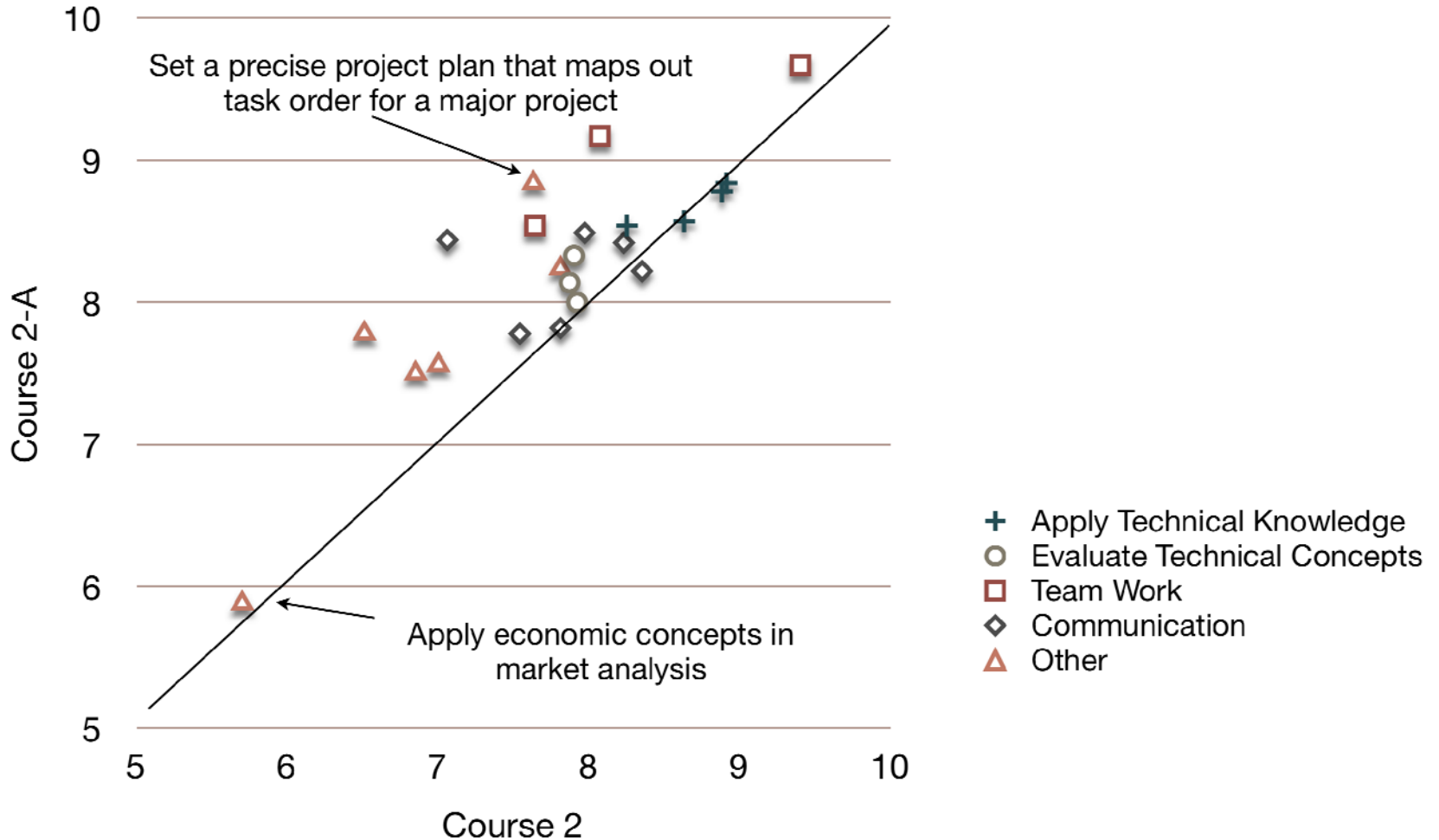


Course 2-A (i.e. flexible degree) in existence since 1934

Course 2-A became ABET accredited in 2002

Work of Peko Hosoi, Professor in Mechanical Engineering, MIT

Confidence Levels of 2 versus 2-A (current students)



Conclusions

- Look-ahead assignments requiring significant self-directed learning improve effectiveness of concept-based lecturing
- Though initially hesitant, students recognize the benefits of these ‘non-traditional’ pedagogies
- Flexible degrees may provide a method to improve training of engineers to solve complex societal problems
- Flexible degrees offer a programmatic avenue for self-directed learning