Intro Physics in USA

Strategies for N>100

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Where I've been

Buffalo State College (2006-)

5+ Physics Faculty

Dartmouth College (2003-2006)

35+ Physics Faculty

North Carolina State University (1997-2003)

40+ Physics Faculty

Course/audiences (nearly universal in US)

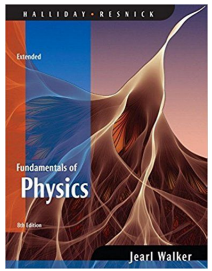
University Physics

For engineers, chemists, physicists

Calculus-based

Mechanics (16 weeks)

E&M (16 weeks)



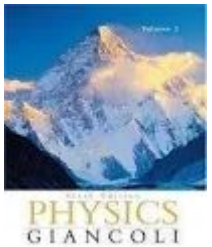
College Physics

For biologists, premeds

Algebra-based

Mechanics (16 weeks)

E&M (16 weeks)



Enrollment (US)

Introductory physics course enrollments at physics departments, academic year 2007-08.

Highest physics degree offered by department	Calculus Based	Algebra Based	Conceptual
Bachelor's	49,000	48,000	30,000
Master's	18,000	18,000	13,000
PhD	112,000	87,000	32,000
Total	179,000	153,000	75,000

http://www.aip.org/statistics

Semester schedule (e.g. NCSU, UB)

16 week terms (August-December, January-May)

5-7 hours / week

- 3 hours lecture (50-300 students, led by faculty)
- 2-3 hours lab (20-25 students, led by graduate student)
- 1 hour additional instruction (20-25 students, led by graduate student)

Institutional support

Faculty

Professional staff

- Teaching faculty
- Lab support professionals

Graduate/Undergraduate Teaching Assistants

Non-personnel (demo facility, space, equipment money)

Large enrollment v1.0

Standardized textbook (name an author…)

Lecture

- Instructor talks, provides visuals
- Student listens

“Cookbook” labs (created locally)

- Instructor provides recipe
- Students fill in forms, verify physics

Homework

- Student reads text?
- Student does problems
- Instructor gives feedback

Exams

- Instructor certifies student learning
- Problem solving focus

Large enrollment at UCM

How does UCM model compare to US v1.0? What's similar? What's different?

What skills do you want intro physics students to learn?

What are strengths and weaknesses of UCM intro course model?

Keep v1.0?

Keep v1.0…

Easy (for institutions, instructors and students)

Meets expectations (of instructors, students)

Inexpensive to institution

Already tailored to institutional constraints

Fix v1.0…

Students don’t learn much about physics concepts in v1.0:

$$\langle g \rangle = 0.1 \pm 0.1$$

Standard curriculum not valued by some disciplines

Student textbook costs

Tweaks to v1.0

	Primary Strategy
Lecture	Get students involved! Attend to conceptual difficulties
Lab	Use curricula informed by ...
Recitation/Discussion	Student group work, research informed curricular materials
Book	Use open copyright book to cap student cost
Homework	Online HW

See https://www.physport.org/methods/ for large list

Tweaks to Lecture v1.0

Interactive Lecture Demonstrations

Just in Time Teaching

Audience polling (aka teaching with clickers)

Think/Pair/Share

Attention to conceptual understanding

Tweaks to Lab v1.0

Real Time Physics

Investigative Science Learning Environment

Scientific Community Laboratories

Local efforts tied to backwards design

Tweaks to Recitation v1.0

Student groups work on targeted problems; instructor circulates and guides students

Research-based/research-informed problem sources

- Tutorials in Introductory Physics
- Ranking Tasks
- Open Source Tutorials
- Tasks Inspired by Physics Education Research (TIPERs)

Tweaks to Book

Open source textbooks (e.g. OpenStax)

Low/no cost to students (Spanish language?)

Online homework

Automated delivery/grading of homework

External commercial hosting

Moderate cost (to students)

Variety of problems

No intrinsic learning benefit

Can tweaks work?

Students learn more if tweaks are well executed:

$$\langle g \rangle = 0.4 \pm 0.1$$

Poll questions

What is your level of interest in…

1) New pedagogy for introductory courses
2) Teaching large courses
3) Reforming instruction
4) Theoretical physics

(A) none (B) a little (C) some (D) high (E) very high

Poll questions (revenge)

What (do you think) is the typical College Physic student's level of interest in...

1) Taking large courses
2) Reformed instruction
3) Theoretical physics

(A) none (B) a little (C) some (D) high (E) very high

How change happens (or not)

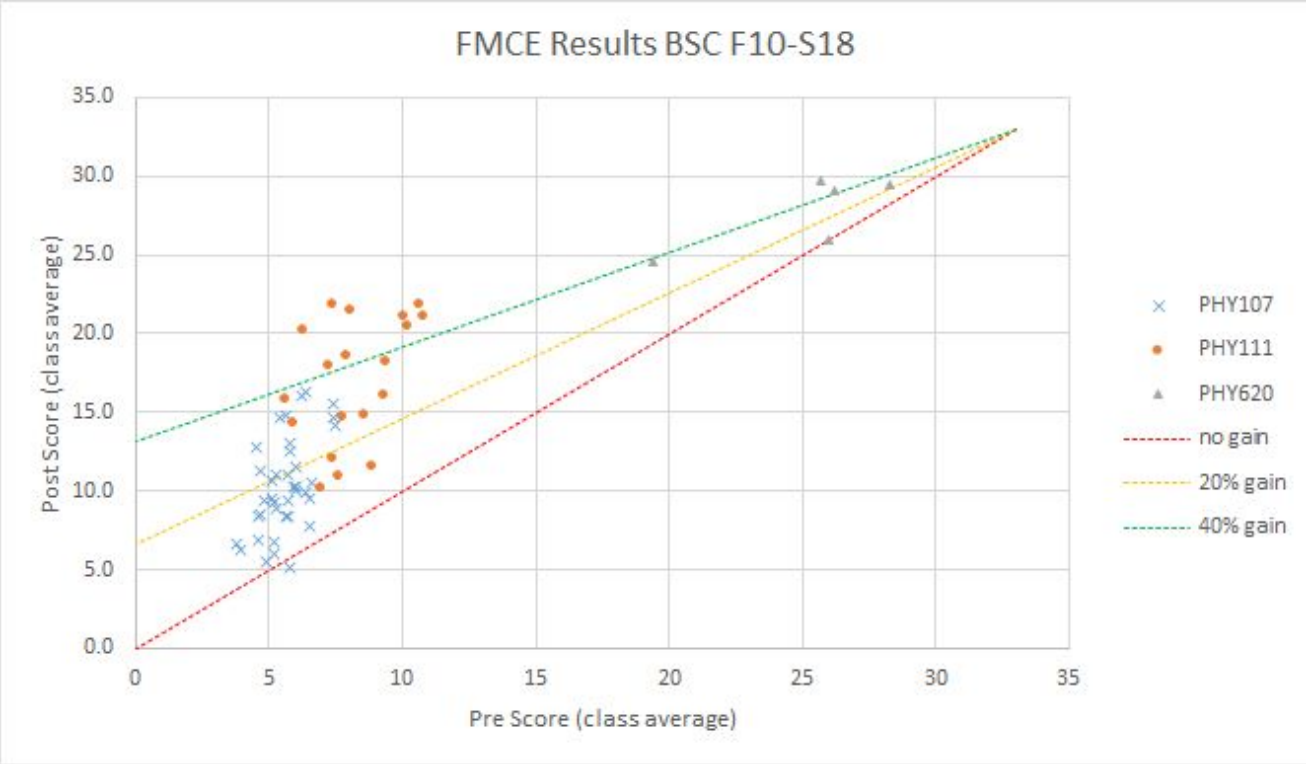
By person

- Incremental
- Depends on individual motivation
- Institutional constraints
- Limited results
- Must get students to buy in

By institution/department

- Initial change can be drastic (and still succeed!)
- Large effort- requires external motivation (threat)
- Must get students to buy in
- Requires maintenance
- Useful success story = University of Illinois

Individual instructor change model



Resources

Physport.org (Website with lots of teaching resources)

Freeman et al. PNAS June 10, 2014. 111 (23) 8410-8415. Active learning increases student performance in science engineering and mathematics. http://www.pnas.org/content/111/23/8410

Parallel parking an aircraft carrier, PhysTEC Conference (2009). https://www.phystec.org/items/detail.cfm?ID=8718

http://demoroom.physics.ncsu.edu/ (lecture demonstration site at NCSU)