

Few slides from the study:

Exploring the Gender Gap in Undergraduate Physics

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“Gender differences in Undergraduate Students’ Participation, Perception and Performance in Physics”

What do we know?

- Females are greatly under-represented in STEM courses both at secondary and tertiary level.
- Large gender gap in school influencing the gap at university entry level
- Proportion of women studying Physics at university has remained 18-20% in the UK over the last decade

What do we know?

- Literature proposes many factors which may affect the uptake and performance of physics and other STEM courses by girls
 - Stereotype threat
 - Cognitive or Psychological gender differences
 - Imposter syndrome
 - Family and teacher support
 - Link between attitudes and success

What do we know?

- Females often out-perform males in school leaving exams
- Evidence suggests females under-perform compared to males in STEM subjects at university

Participation

Percentage of females in introductory physics course

24% between 2006-2014

Comparable to female percentage in Higher/A-level

Much lower than in other STEM subjects

40% College of Science and Engineering

56% University of Edinburgh

Participation

⇒ Do there exist large differences between the reasons for males and females choosing to study physics at university?

No gender differences in reasons for choosing degree programme

No gender differences in reasons for transferring out of degree programme

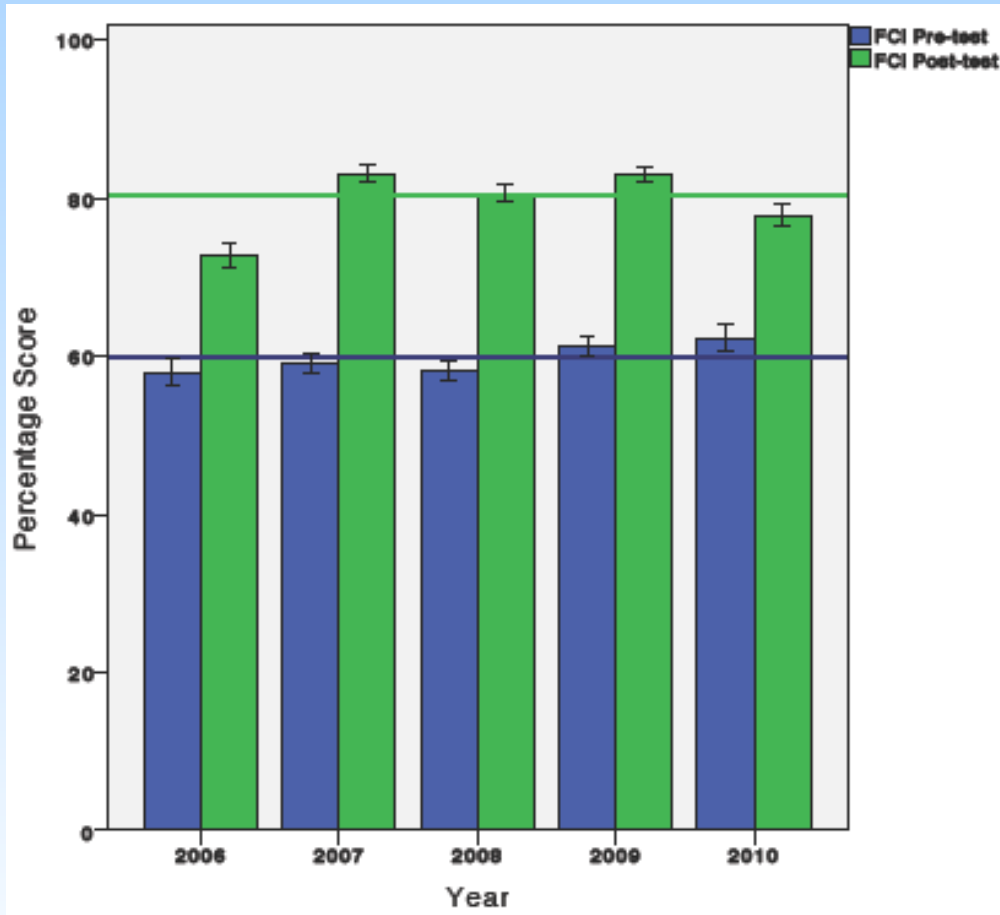
Participation

- Consistency of proportion of females in university physics courses suggest that it is very difficult to influence change once students have chosen the subjects that will dictate their university choices.
- Need to target issue earlier in students education
- But also ensure that we maintain students' interest once they have reached university

Performance

- Are students showing an increase in conceptual understanding over the semester?
- Is there a significant gender difference in physics performance?
- Are gender differences dependent on the type of assessment – coursework, labs or exams?

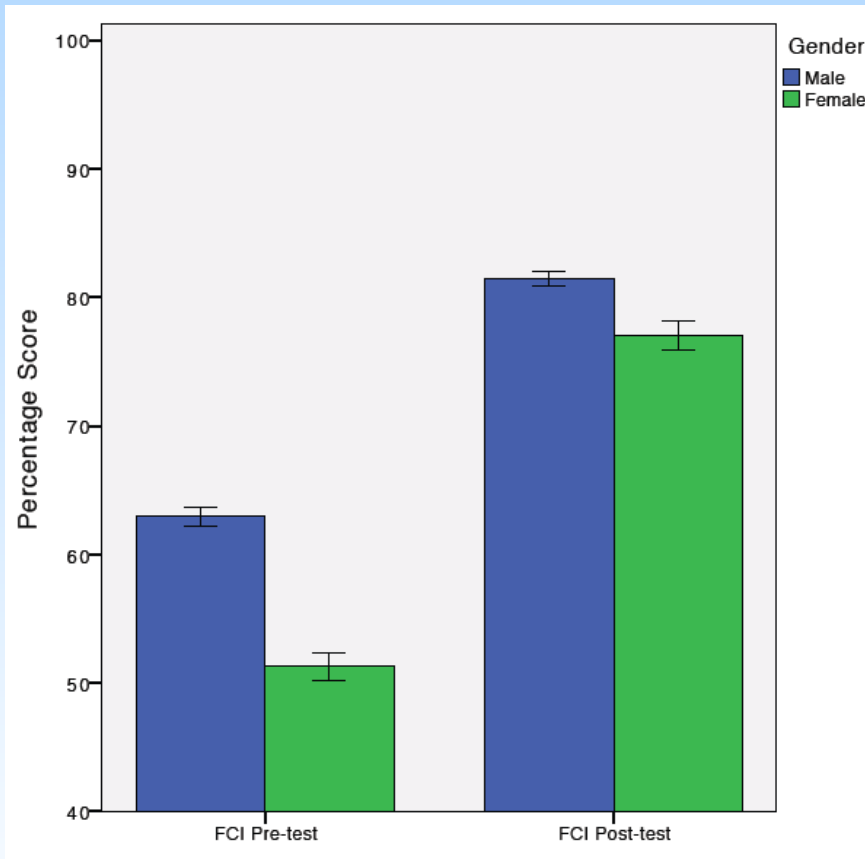
Performance



Consistent improvement over one semester in student performance on conceptual diagnostic test

Average learning gain
= 0.48

Gender Performance



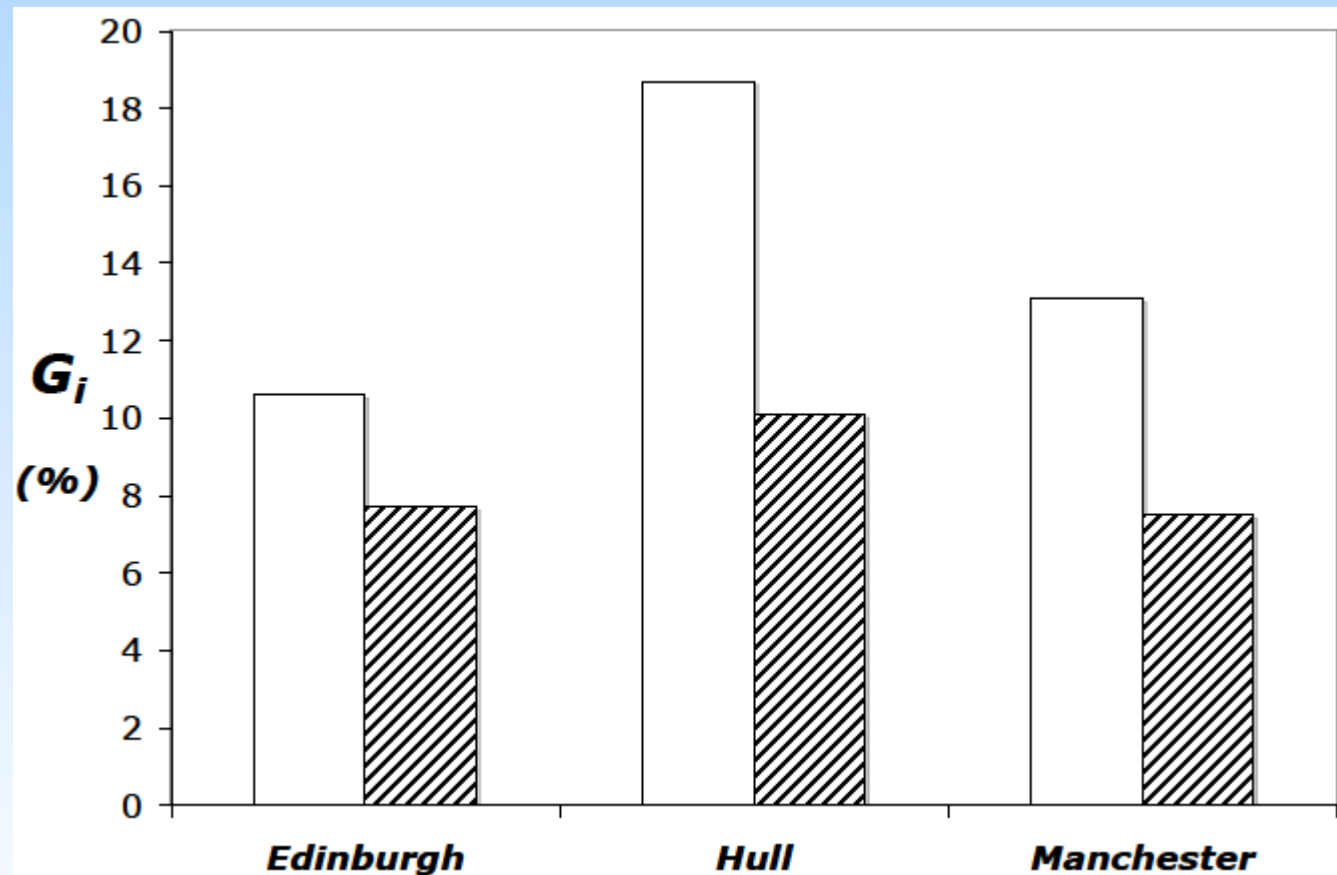
Males outperformed females significantly at the beginning of the introductory physics course each year

Gender gap decreased

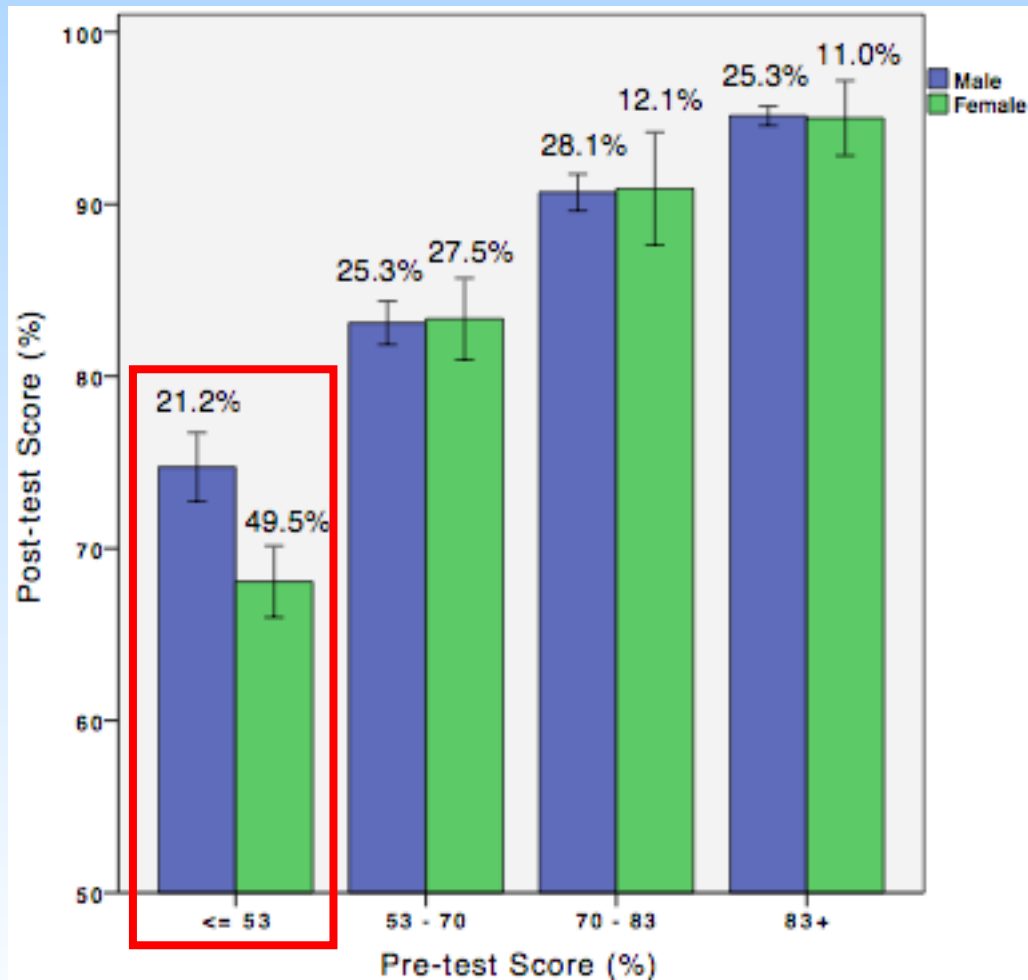
12% → 4%

But females continued to statistically under-perform compared to males

Is this an effect seen only at Edinburgh?



Gender Difference in Post-Instruction Score as a function of Pre-Instruction Score



- Students who completed both pre and post test were binned into 4 cohorts of equal size dependent on Pre-Instruction score

- Males distributed relatively evenly between quartiles

- Bottom quartile comprises 50% of entire female population

Top quartile contains only 11% of female population

- **Statistical difference between genders in lowest quartile**

- **Results replicated at University of Manchester and University of Hull**

What did these results tell us?

Students have clear misconceptions about certain physics concepts

E.g. Motion implying an acting force

Newton's Third Law

Impetus

Misconceptions in Physics often related to “real-life” experiences

Not all misconceptions held to the same degree by males and females

Different multiple-choice distractors chosen on MCQ questions.

Need to target origins of misconceptions and highlight them to students early in the course

Gender Differences: Student Confidence

- Interviewed male and female student at University of Edinburgh, University of Hull and University of Manchester
- Students worked through the problems one by one and explained their reasoning
- Students' responses were coded for
 - Whether they answered correctly / incorrectly
 - How confident they were about their answer

Female students were more likely than males to answer incorrectly

Females: 30% Incorrect Males: 13% Incorrect

Male students more likely to show confidence in correct responses

Males: 74% 'Very Confident' & Correct Females: 50% 'Very Confident' & Correct

Female students more likely to be confident in an incorrect response

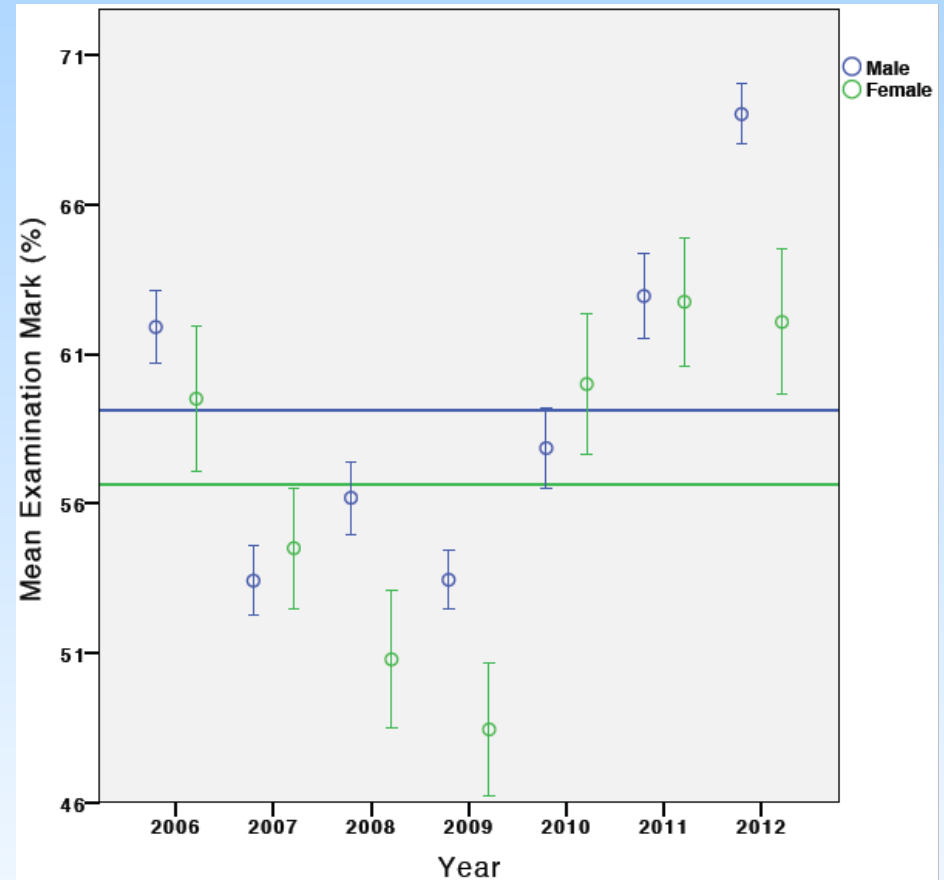
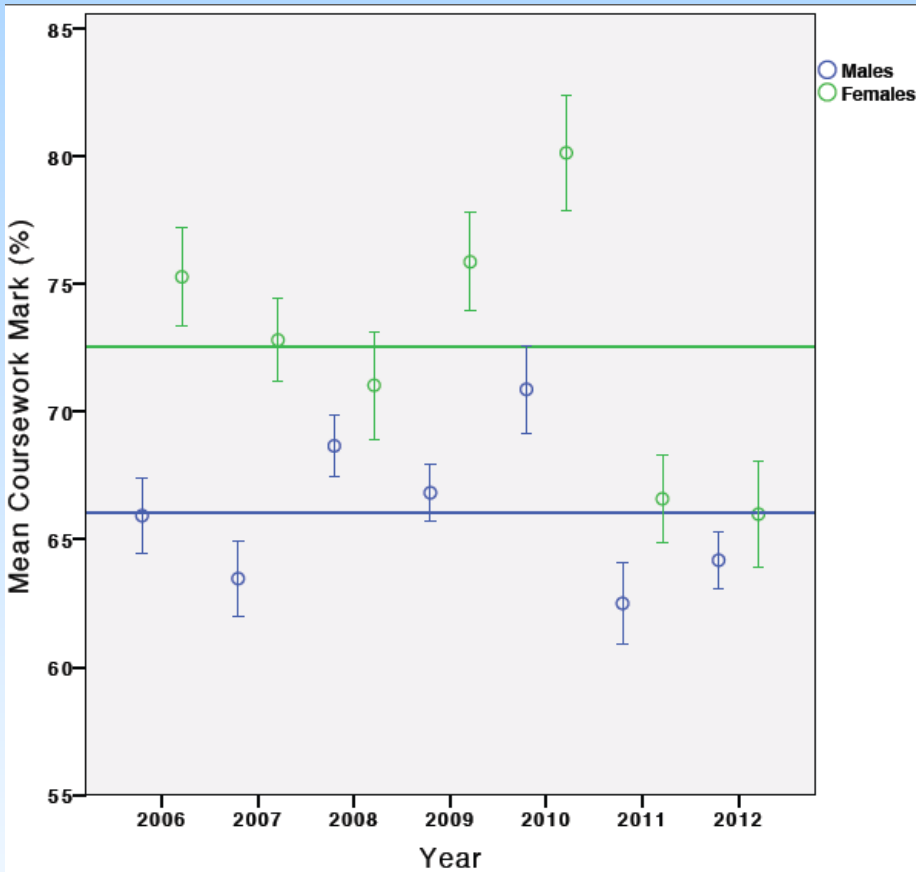
Females: 14% Incorrect and Confident Males: 1% Incorrect and Confident

- Females were more likely to hold on to their preconceptions than males and choose an answer based on their first instinct whilst males considered each possible answer option before stating their final response to the question

Assessment

- Previous studies have suggested that students perform differently depending on the type of assessment administered
- Studies have shown gender differences on coursework and exams
 - Female students work better in a group environment
 - Male students perform better in exams which involve working individually under a small time pressure

Analysis conducted of 1st year coursework and exam results



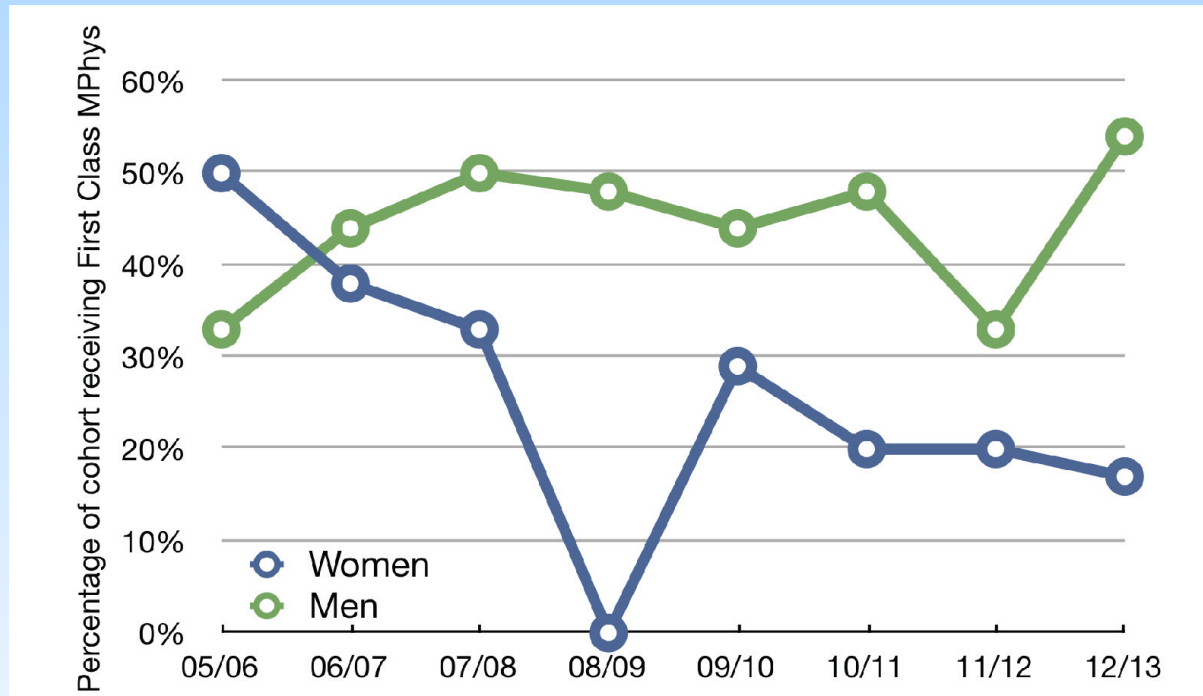
What do we need to consider?

Comments from graduating students of both genders discussed issue of coursework and open book exams

- promote more productive learning than closed book examinations only?
- coursework allows students to judge their own progress
- more feedback...

Be aware of the opportunities for different teaching methods/learning environments

Degree Classification



Degree Classification

Classification	MPhys Degree				BSc Degree			
	1	2.1	2.2	3	1	2.1	2.2	3
% of females who receive this degree	18%	64%	18%	0%	28%	37%	32%	4%
% of males who receive this degree	46%	33%	21%	0%	26%	30%	36%	9%
% of this degree classification awarded to females	8%	29%	15%	0%	30%	32%	25%	12%
% of this degree classification awarded to males	92%	71%	85%	0%	70%	68%	75%	88%

Table 2. Percentage of male and female students awarded different degree classifications.

Of all 188 graduating MPhys students in last 5 years

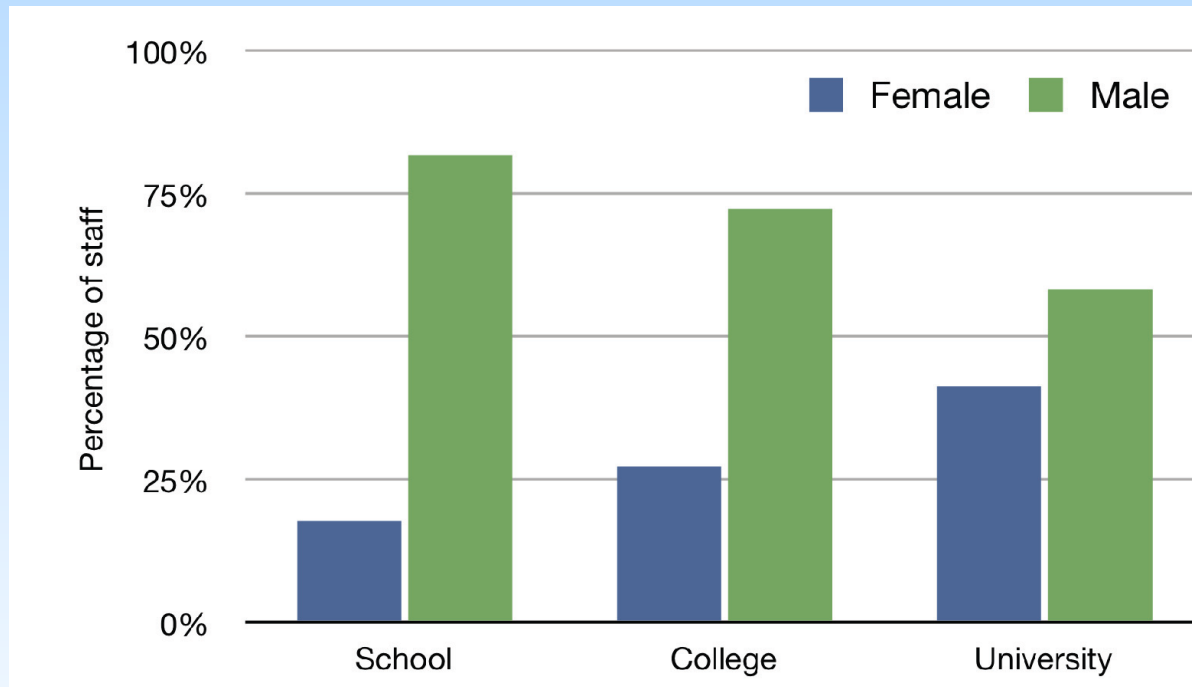
46% of males and **18%** of females received 1st class honours

Of all 206 graduating BSc students in last 5 years

26% of males and **28%** of females received 1st class honours

Data from JUNO Champion Submission

What is the situation like after undergraduate?



Proportion of male and female academic staff in School of Physics and Astronomy, College of Science and Engineering and University of Edinburgh (2013)

Why is this important?

- Increase the number of science students is important for growth of industry and academia
- Important to ensure physics accessible and approachable to those who want to study in this discipline. Why are we losing females in the “leaky pipeline”?
- Need to maintain students’ interest in STEM subjects as they move up through university

Why is this important?

- Student attitudes towards study can affect their course performance and enthusiasm for subject and vice versa.
- Student success in a course can impact whether they continue in the major or as a career
 - Understanding the factors that do and do not promote student learning in a course is crucial to understanding the gender gap and finding ways to eliminate it

Why is this important?

- Important to know the needs of students at which a course is aimed and target areas in which attainment is unbalanced with respect to gender
- Need to identify areas in which females are underperforming in order to help instructors to target difficulties students have with particular concepts for construction of future knowledge concepts
- Can extrapolate results for other disciplines.

backup

- BSc in Physics with Meteorology from University of Edinburgh (2010)
- Started research MSc with Physics Education Research group aimed at explore whether there existed a gender gap in undergraduate physics (JUNO practioner)
- Results extended project to PhD (2014):

“Gender differences in Undergraduate Students’ Participation, Perception and Performance in Physics”

What did my project aim to explore?

- Participation
- Student Performance
- Students' Perceptions and Attitudes towards Physics

What do we know?

- Reports that size of gender gap in performance is related to assessment type or teaching methods
- New teaching methodologies introduced
 - Peer Instruction
 - Flipped/Inverted Classroom

Participation

Students transfer between degree programme due to increased interest in an outside discipline

“Really enjoyed it”

“I felt that I had more career opportunities with Engineering and that studying an applied science would be more useful”

“The change in course had nothing to do with the way Physics was taught...I wanted to know how things were applied, instead of studying the reason for things happening”

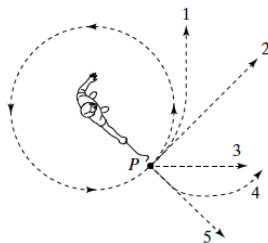
Performance

- Primary focus on 1st year introductory physics courses between 2006-13 (200-300 students)
- Students' understanding measured using Force Concept Inventory pre- and post-testing

7. A steel ball is attached to a string and is swung in a circular path in a horizontal plane as illustrated in the figure below.

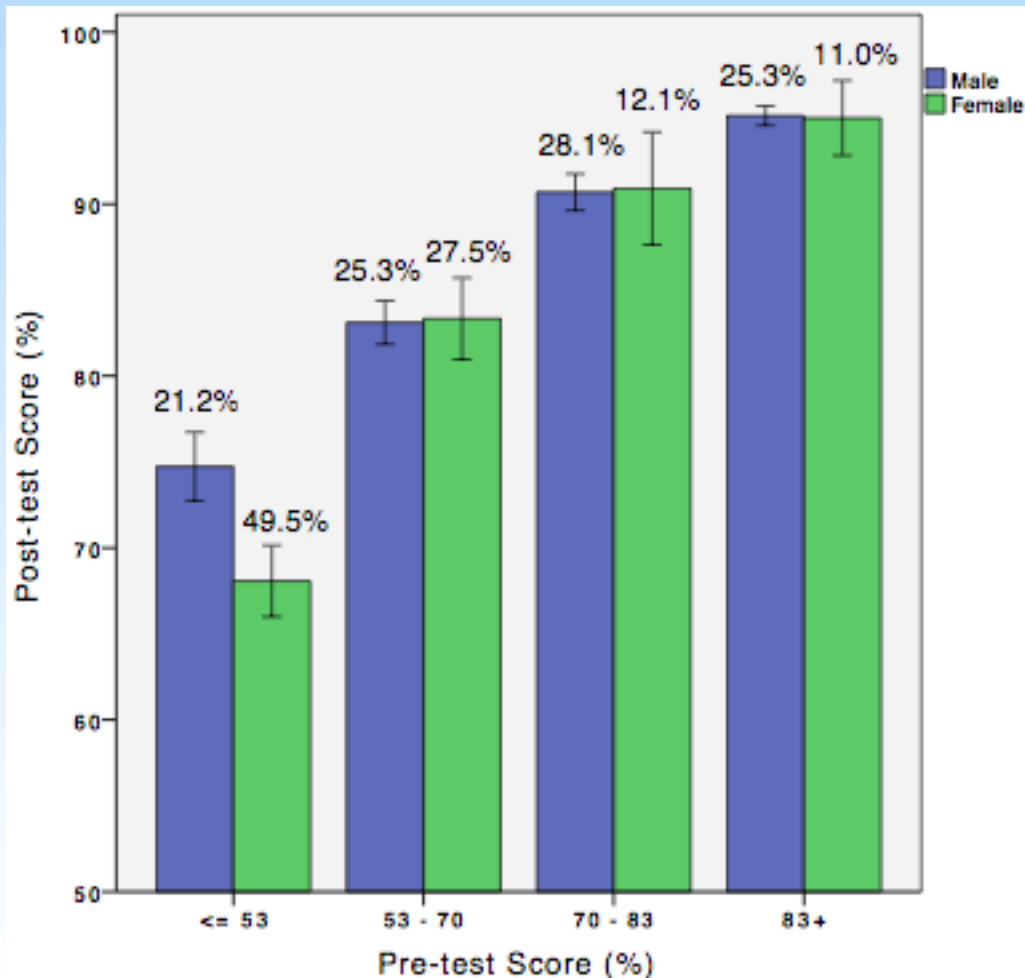
At point P , the string suddenly breaks near the ball.

If these events are observed from directly above, which of the paths 1–5 below would the ball most closely follow after the string breaks?



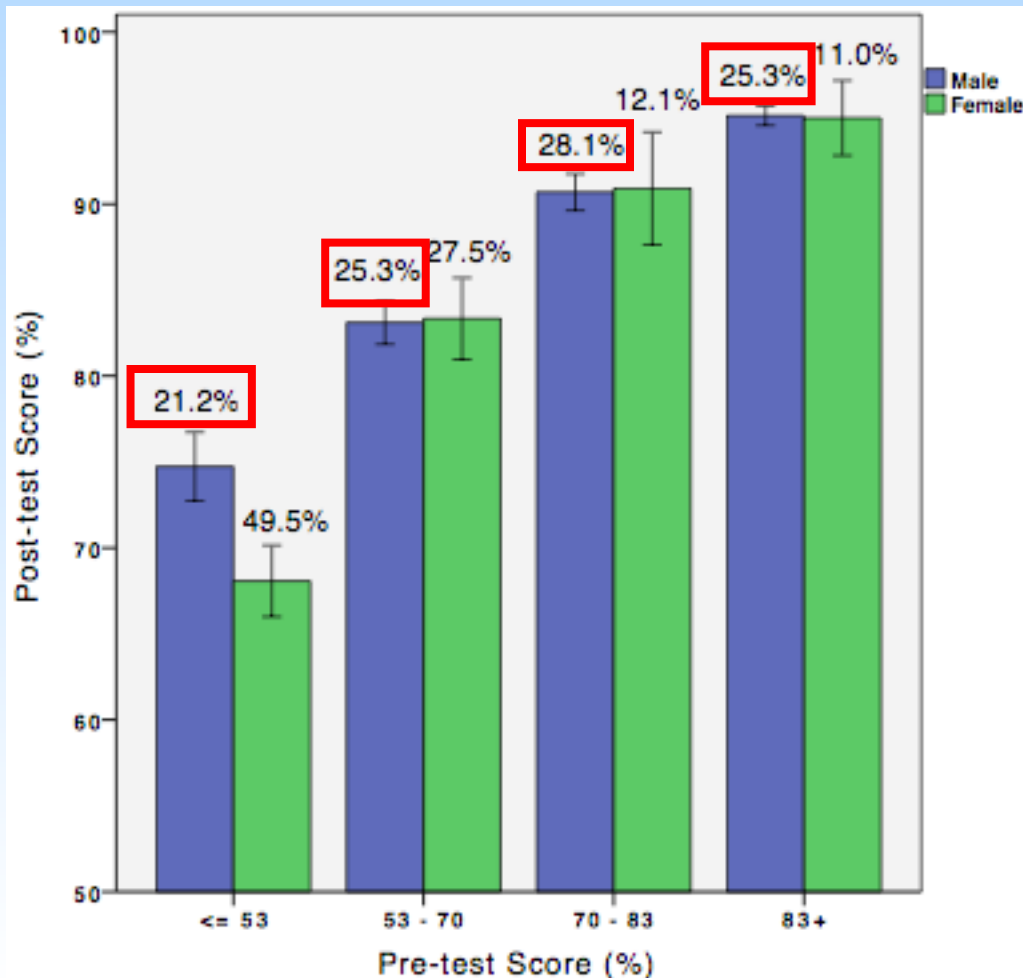
- 30 multiple choice question diagnostic test specifically designed to test students' misconceptions of Newtonian Mechanics

Gender Difference in Post-Instruction Score as a function of Pre-Instruction Score



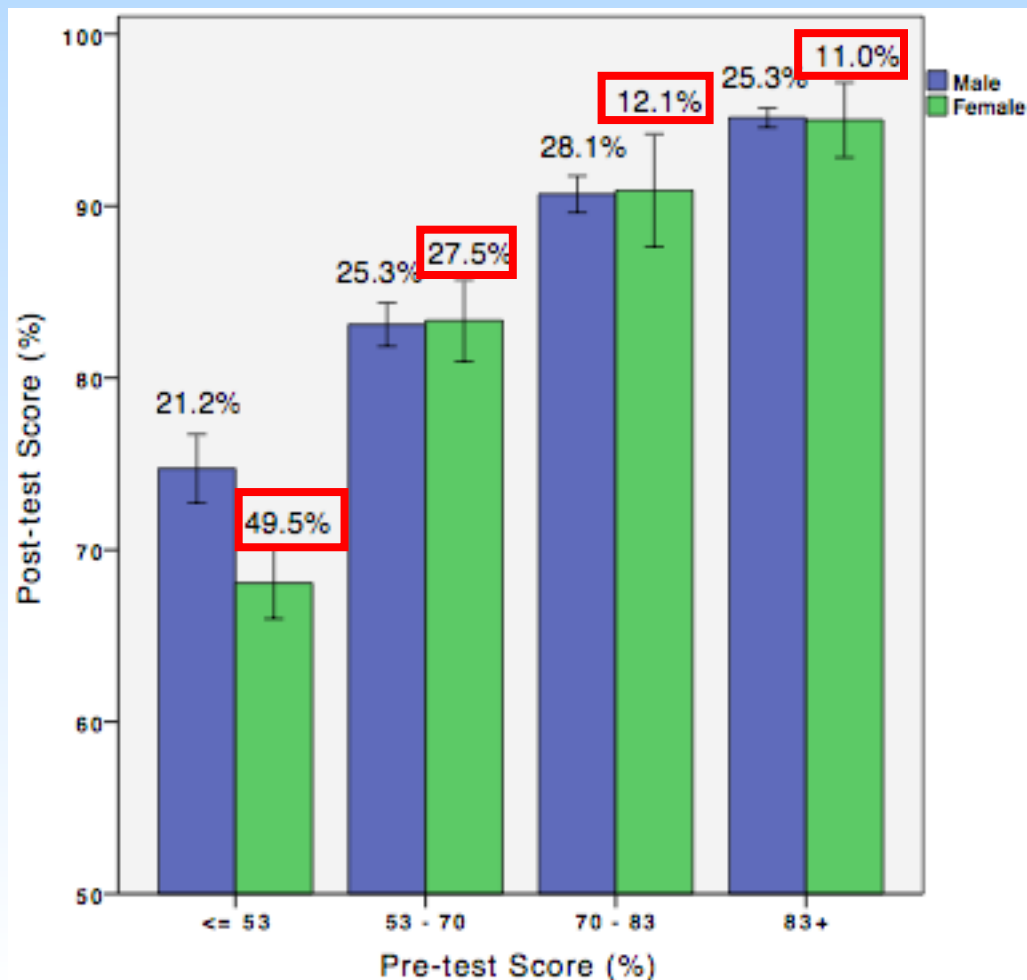
- Students who completed both pre and post test were binned into 4 cohorts of equal size dependent on Pre-Instruction score
- Average Post-Instruction score for each bin calculated as a function of gender

Gender Difference in Post-Instruction Score as a function of Pre-Instruction Score



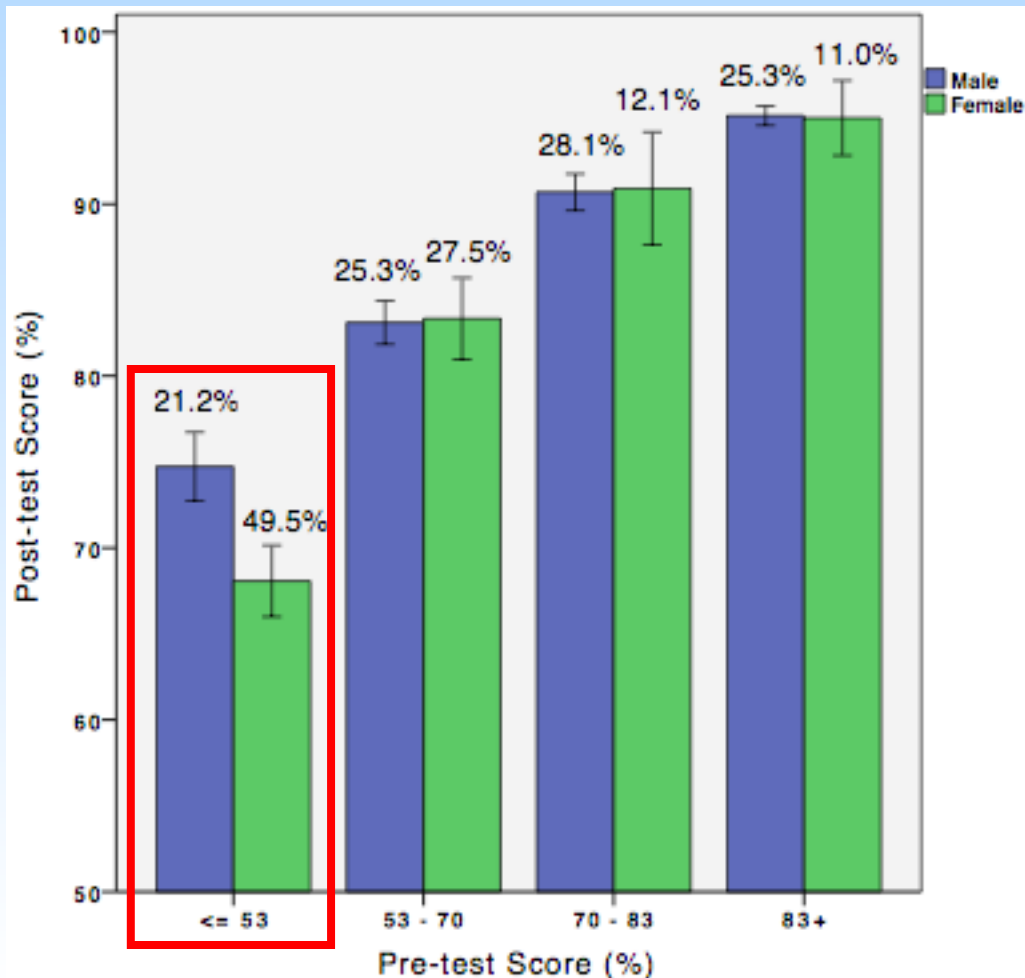
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Assessment

How do we assess our students?

Diagnostic Tests

Peer Assessments

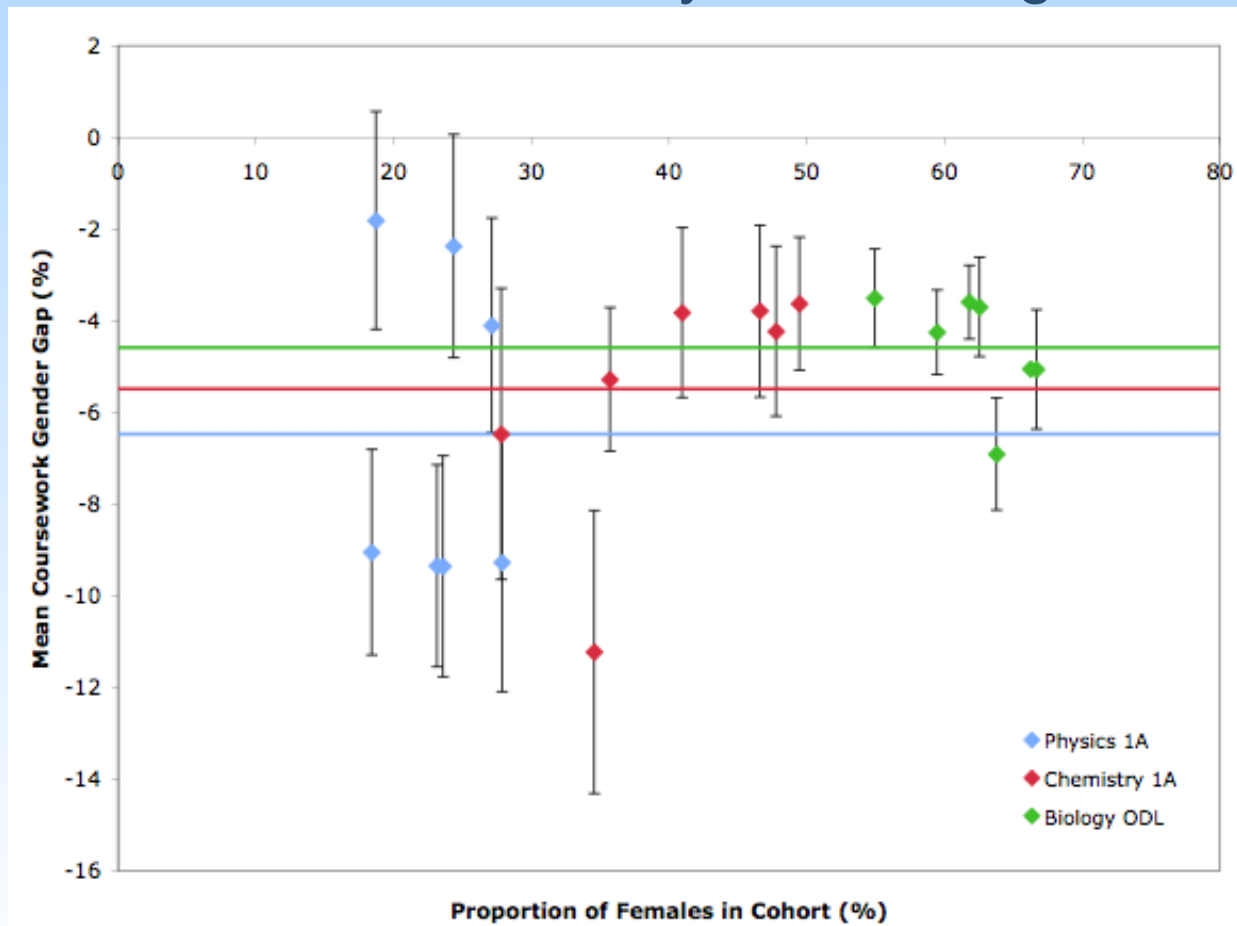
Exams

Coursework

Research Projects

Degree Results

Comparisons made with Chemistry and Biology 1st year courses at the University of Edinburgh



Comparisons made with Chemistry and Biology 1st year courses at the University of Edinburgh

