THE UNIVERSITY *of* EDINBURGH
School of Mathematics

Using item response theory to evaluate a test

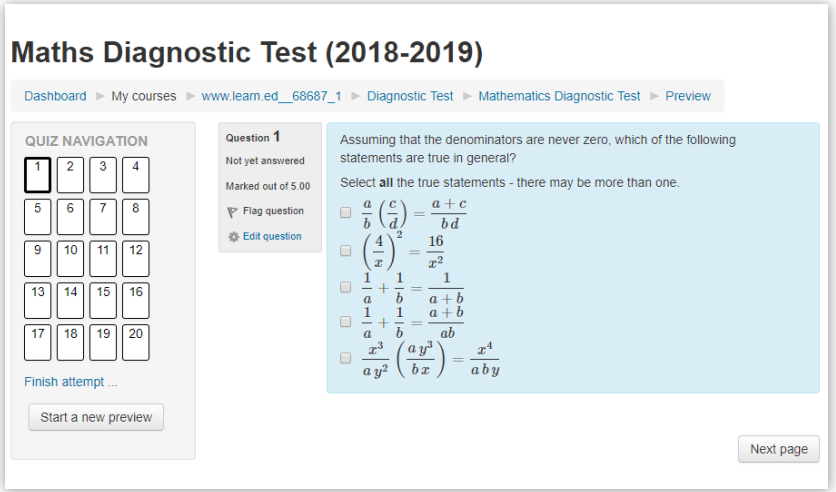
Dr George Kinnear
G.Kinnear@ed.ac.uk
@georgekinnear

Outline

- Background of the test
- Analysis using item response theory
- Implementing and evaluating changes

The Mathematics Diagnostic Test (MDT)

- Administered online to incoming students
  - to help them study
  - to inform decisions
- Multiple choice and numerical answers
- Based on SQA Higher content



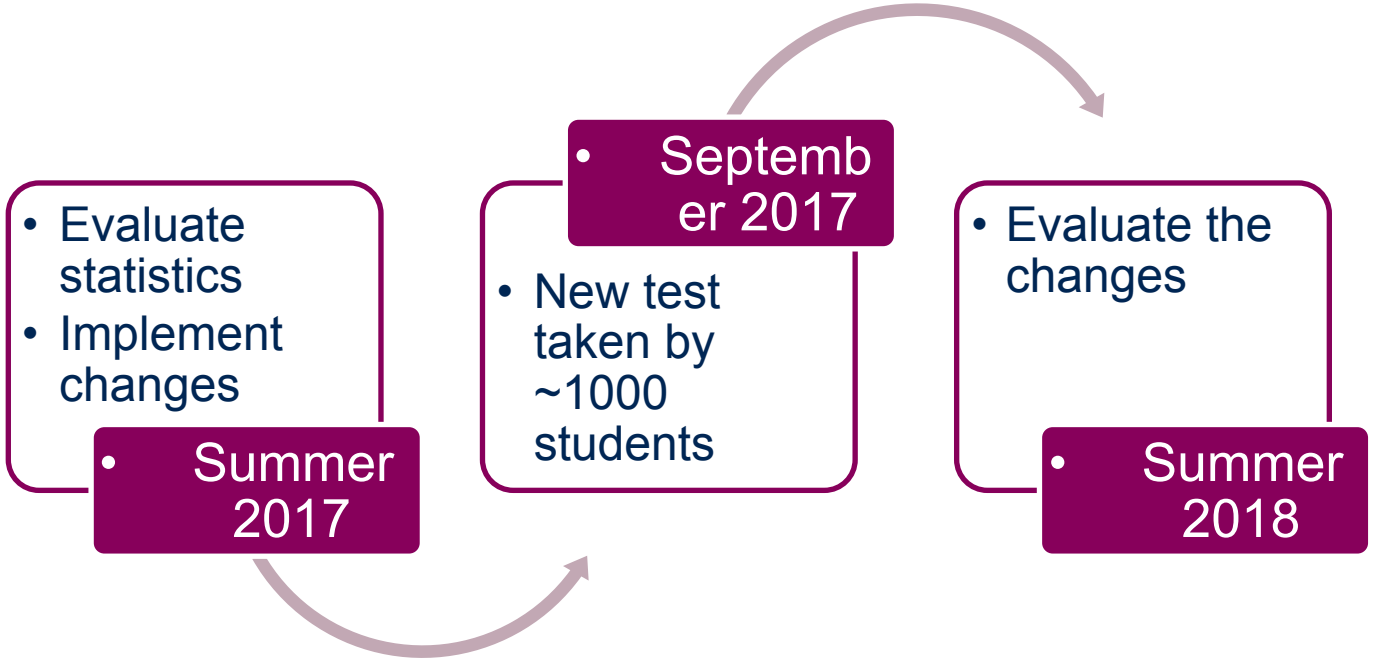
THE UNIVERSITY of EDINBURGH
School of Mathematics

STACK

Improvement project 2017-18

2013-2016

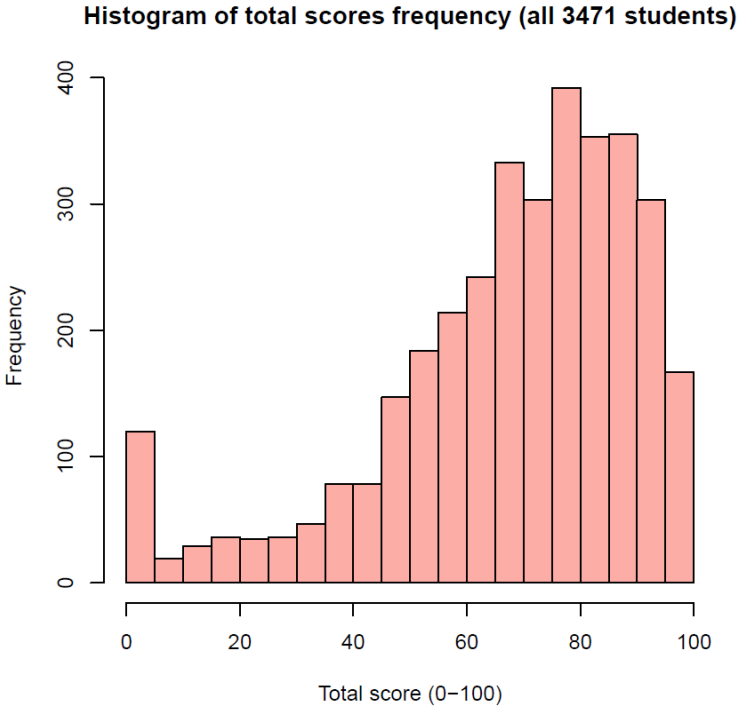
- 20-question test
- Taken by ~3000 students



Analysis

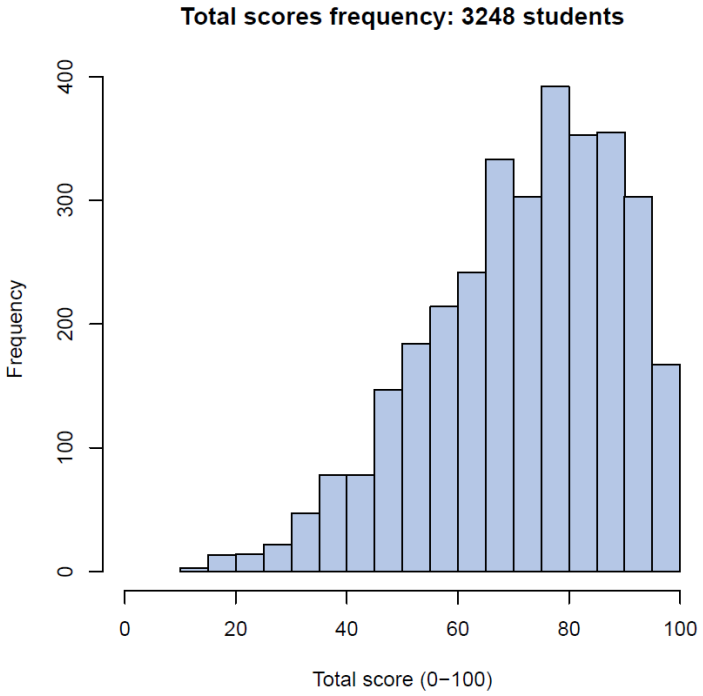
The data

- Raw scores for tests taken in 2013-2016
- Linked to student records (gender, entry qualifications, course results, …)

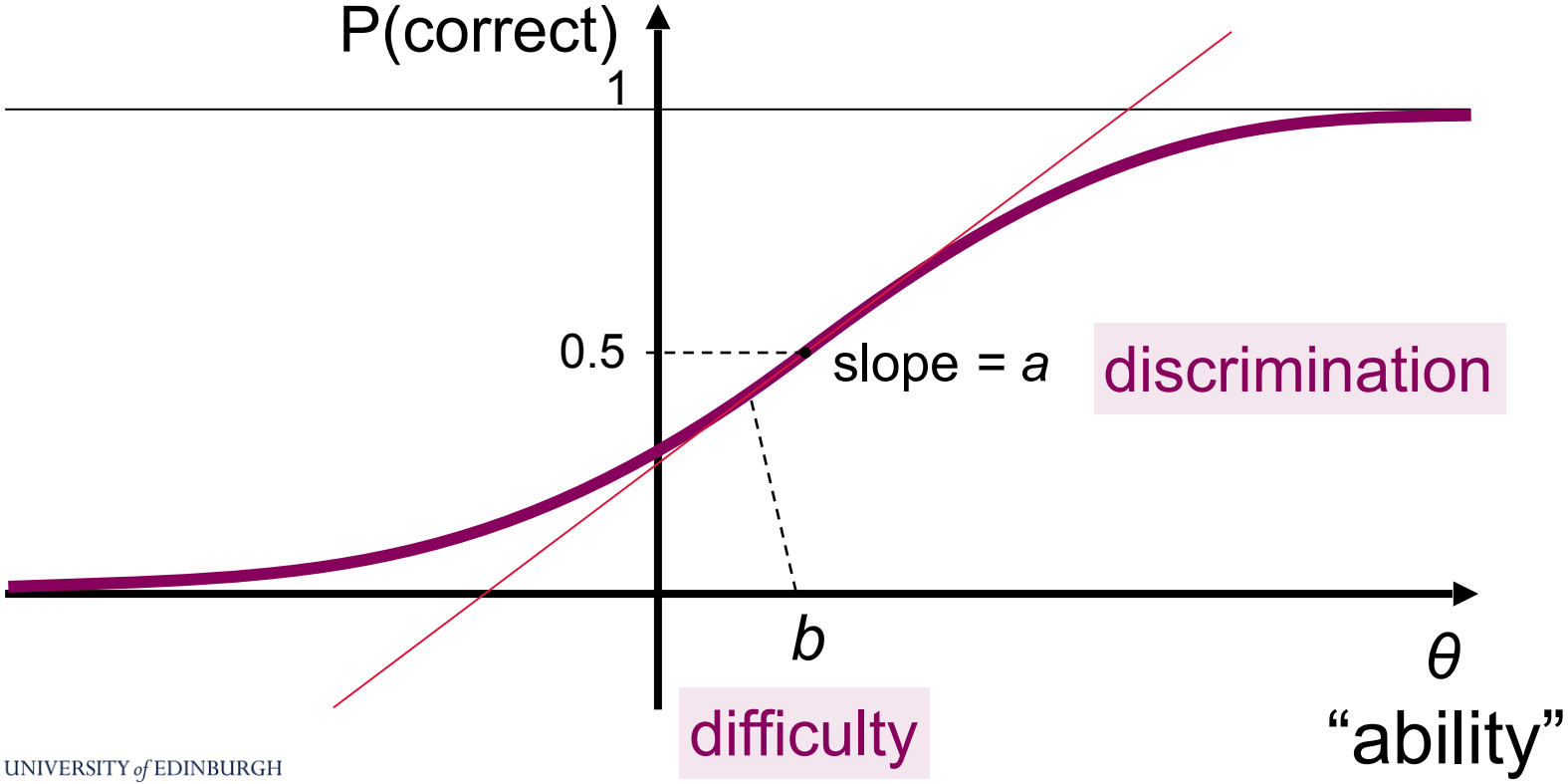


The data

- “Non-serious” attempts were identified and removed

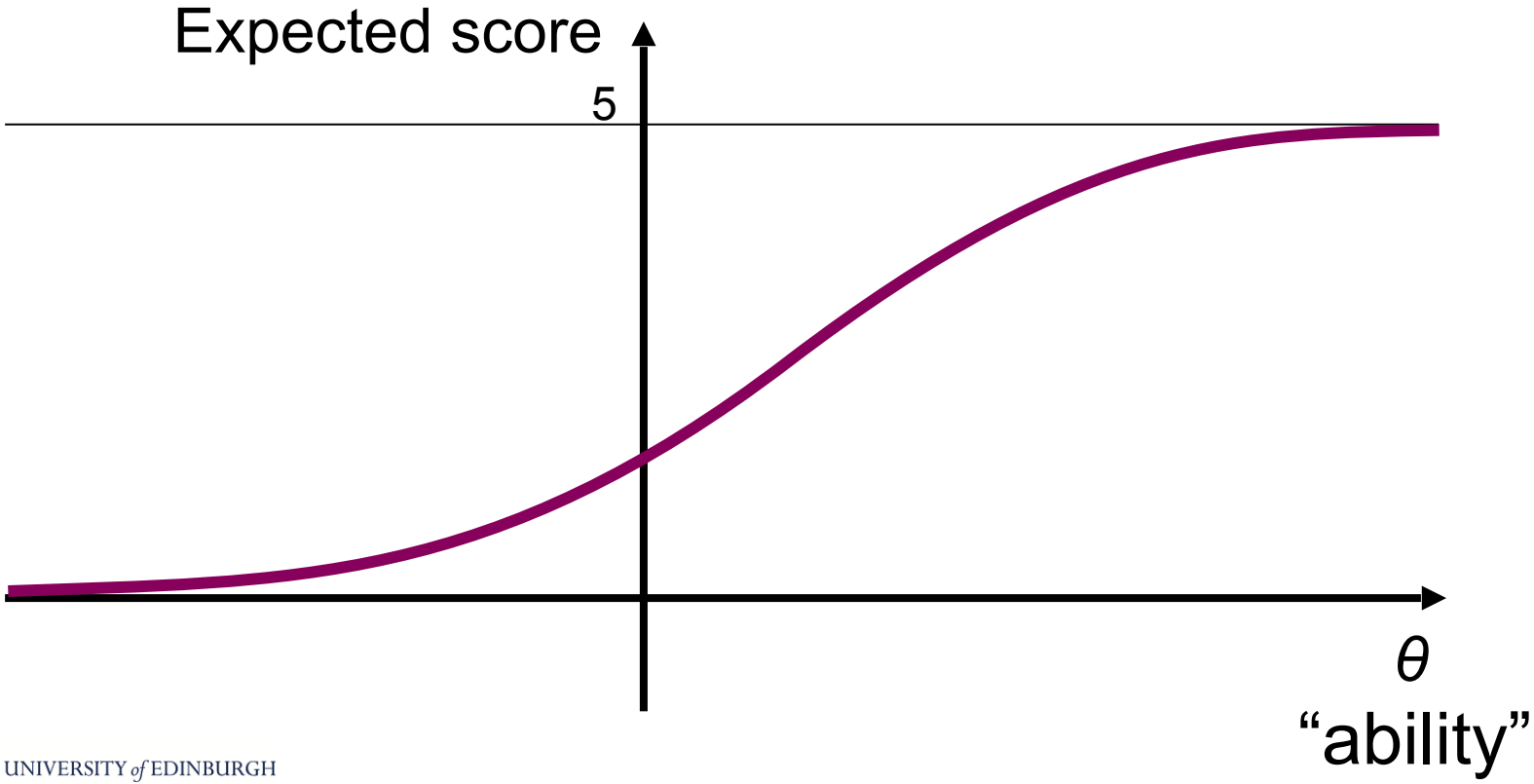


Item response theory

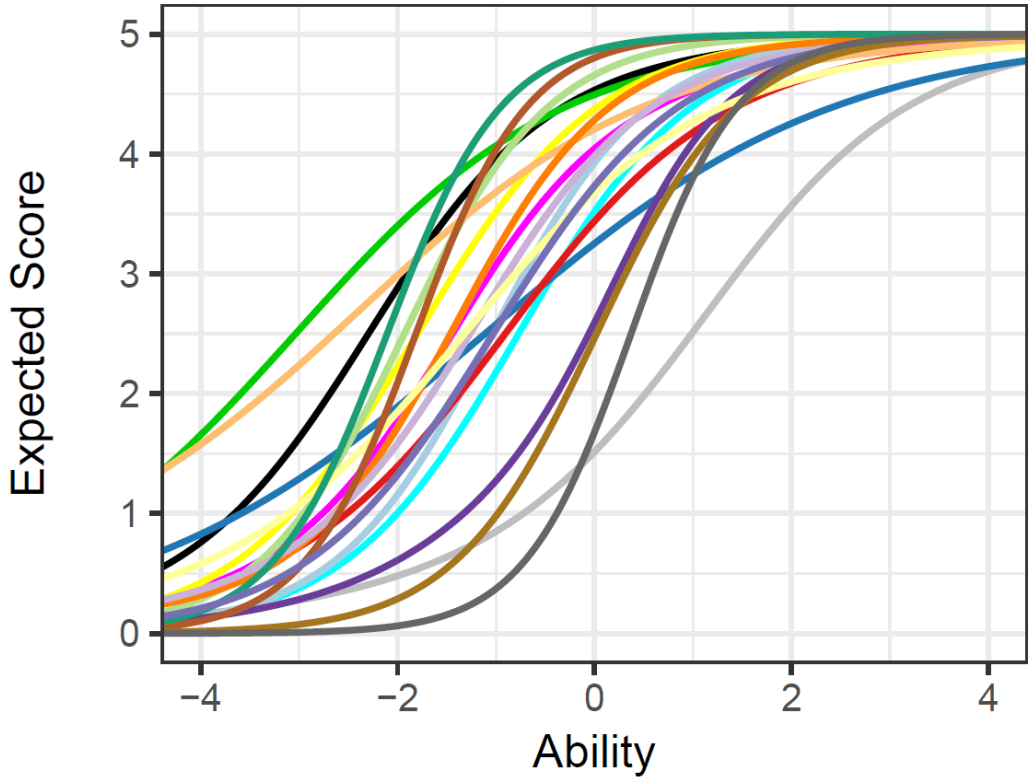


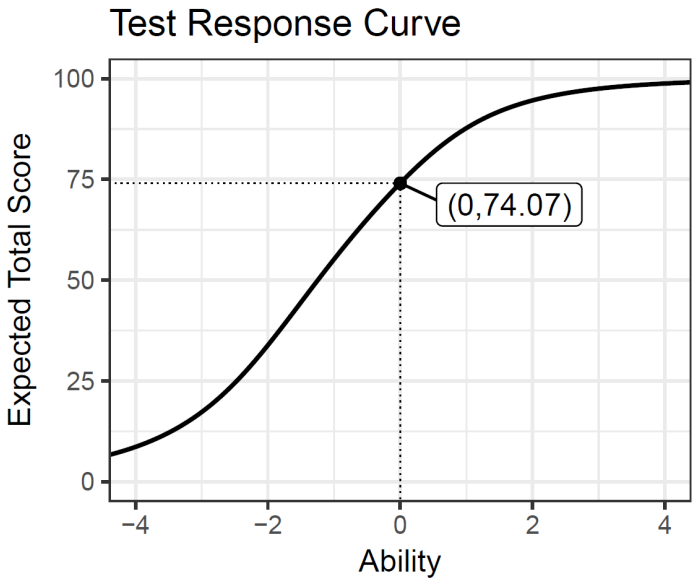
THE UNIVERSITY of EDINBURGH
School of Mathematics

Item response theory – with partial credit

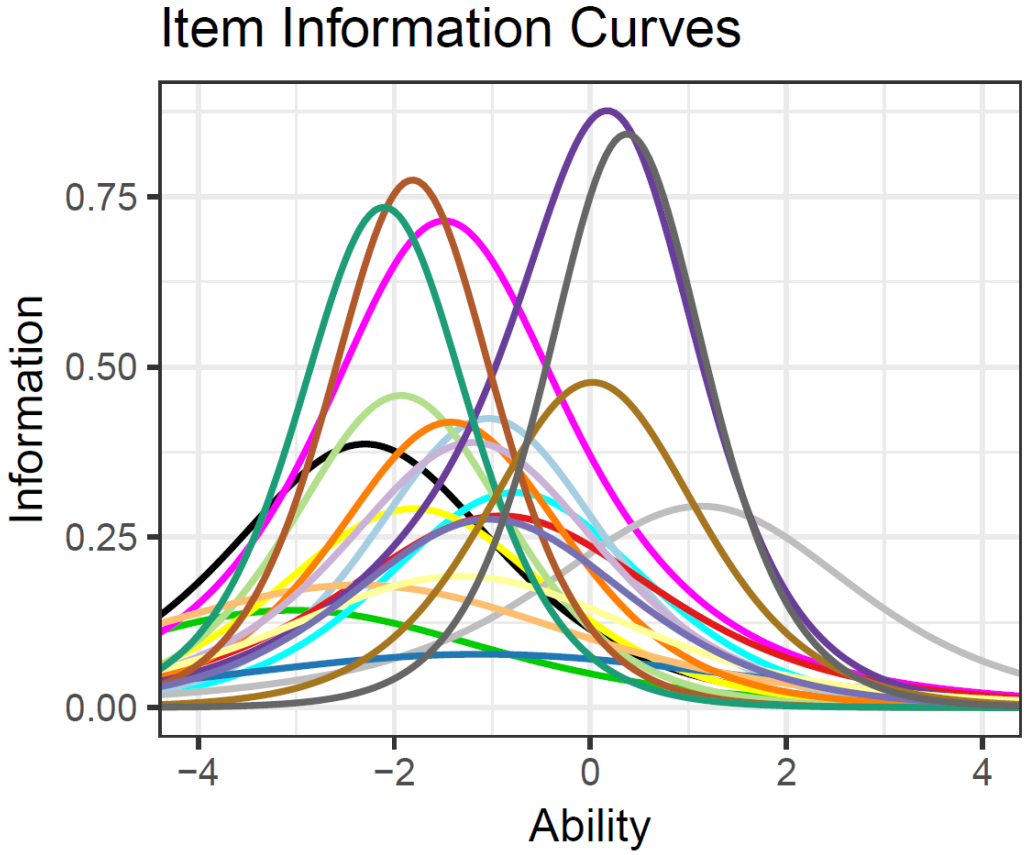


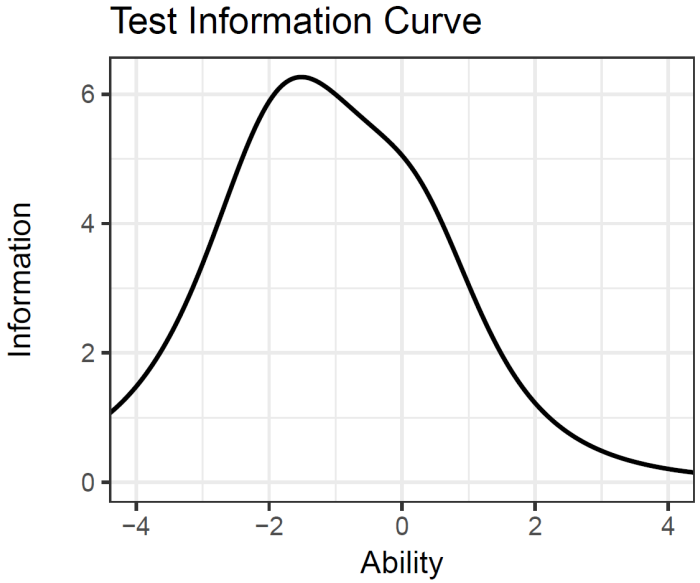
Item Response Curves





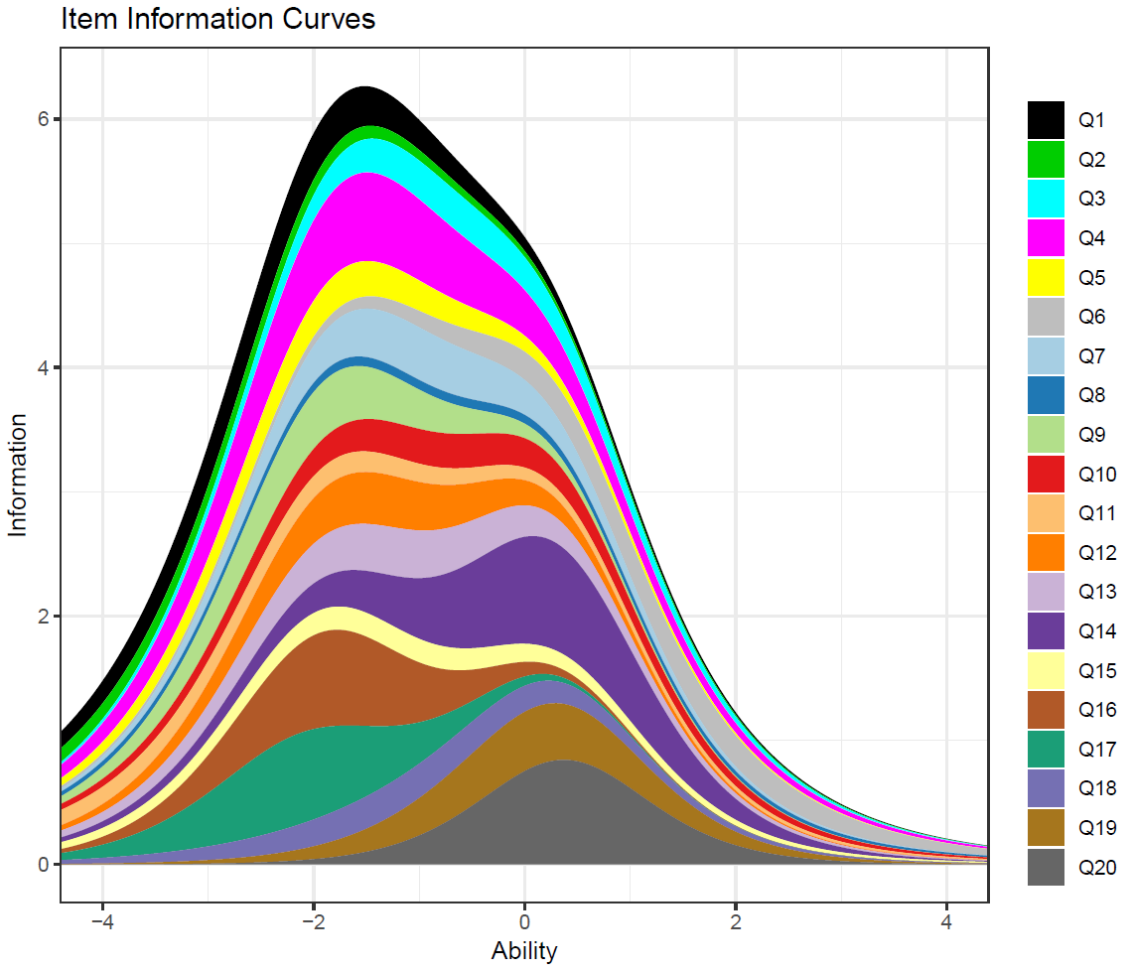
THE UNIVERSITY of EDINBURGH
School of Mathematics





Q1 Q5 Q9 Q13 Q17
Q2 Q6 Q10 Q14 Q18
Q3 Q7 Q11 Q15 Q19
Q4 Q8 Q12 Q16 Q20

THE UNIVERSITY of EDINBURGH
School of Mathematics


Item Information Curves
Information
Ability
0
2
4
6
−4
−2
0
2
4
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q16
Q17
Q18
Q19
Q20

Implementing changes

Changes informed by IRT

- Three questions were removed (Q2, Q8, Q11)
- These were selected because they provided low information
- Three questions were created to replace them

Replacement example

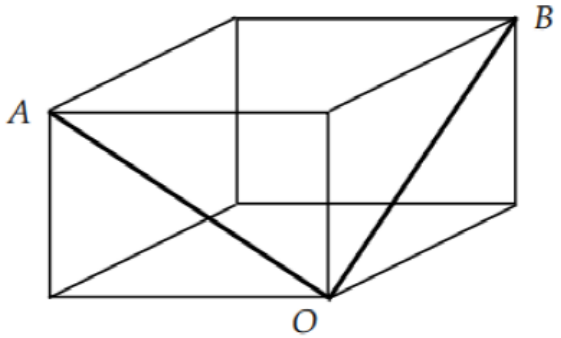
Find the angle between the vectors $(-3, -4, 5)$ and $(-2, -4, -5)$.

Give your answer in radians, accurate to at least 3 decimal places.

Q8

NQ11

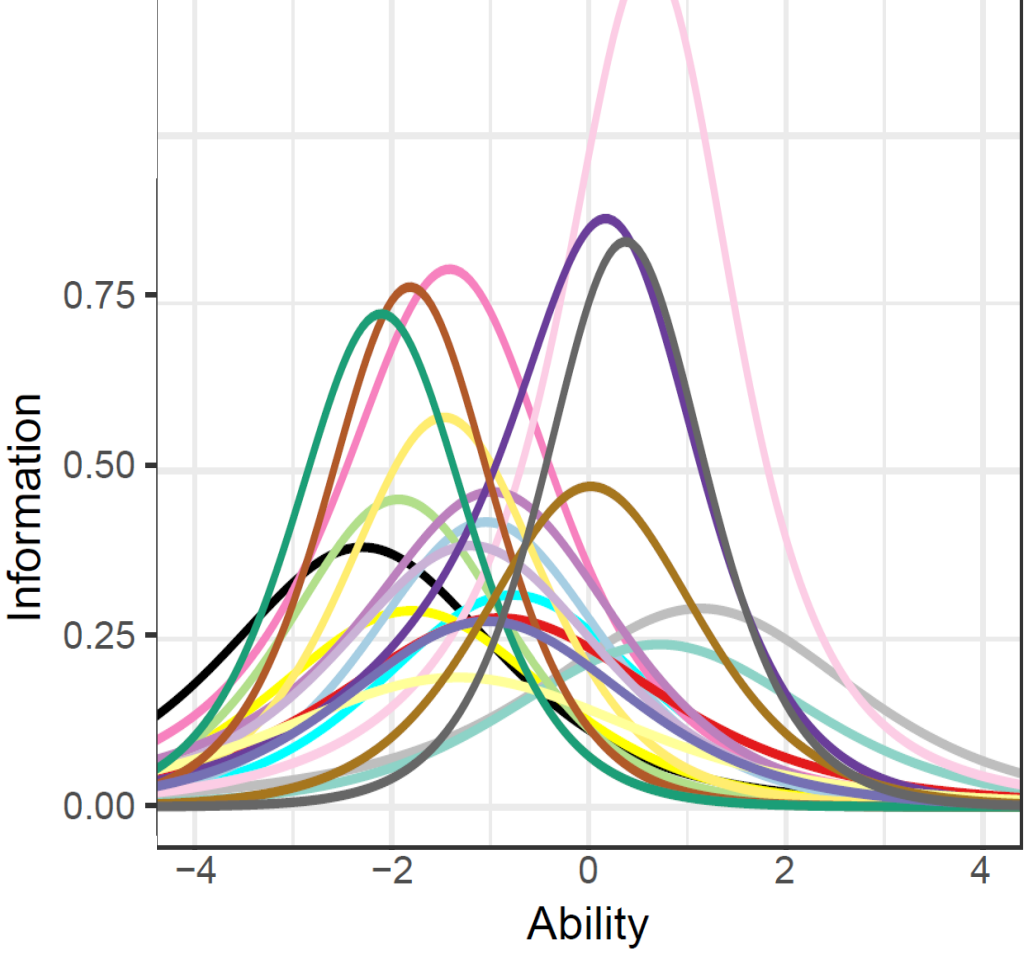
A chemical factory has a rectangular room, with corners A, O and B as shown. The floor of the room is $2\,\mathrm{m} \times 5\,\mathrm{m}$ and the height of the room is $2\,\mathrm{m}$.

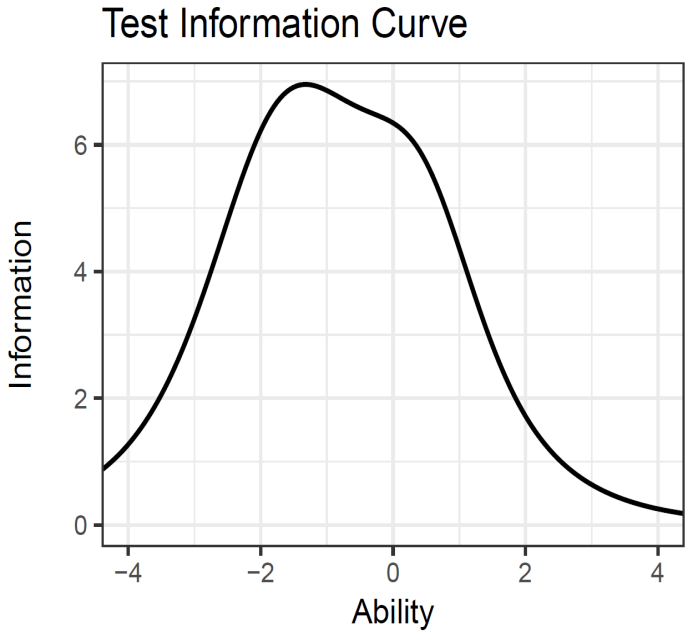


An engineer needs to bend a pipe at O so that it runs in a straight line from A to O, then bends at O, and then runs in a straight line from O to B.

What is the angle of the bend at O? Give your answer in degrees, correct to at least 1 decimal place.

Evaluating the changes



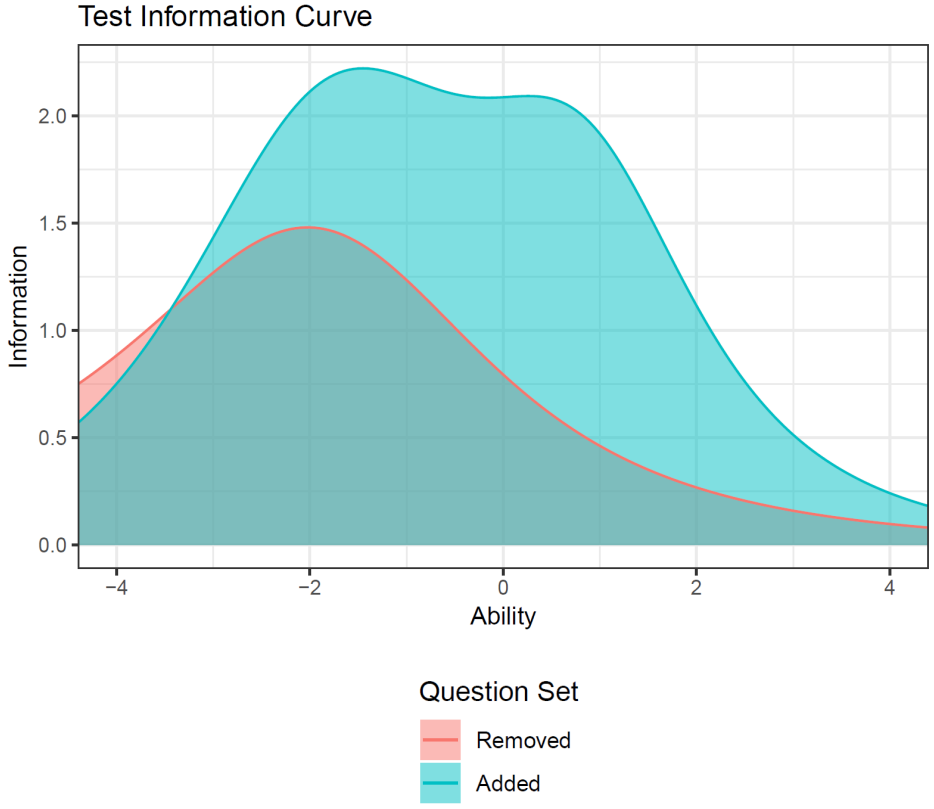


Q1 Q6 Q10 Q13 Q17
Q3 Q7 N10 Q14 Q18
N3 N7 N11 Q15 Q19
Q5 Q9 N12 Q16 Q20

THE UNIVERSITY of EDINBURGH
School of Mathematics

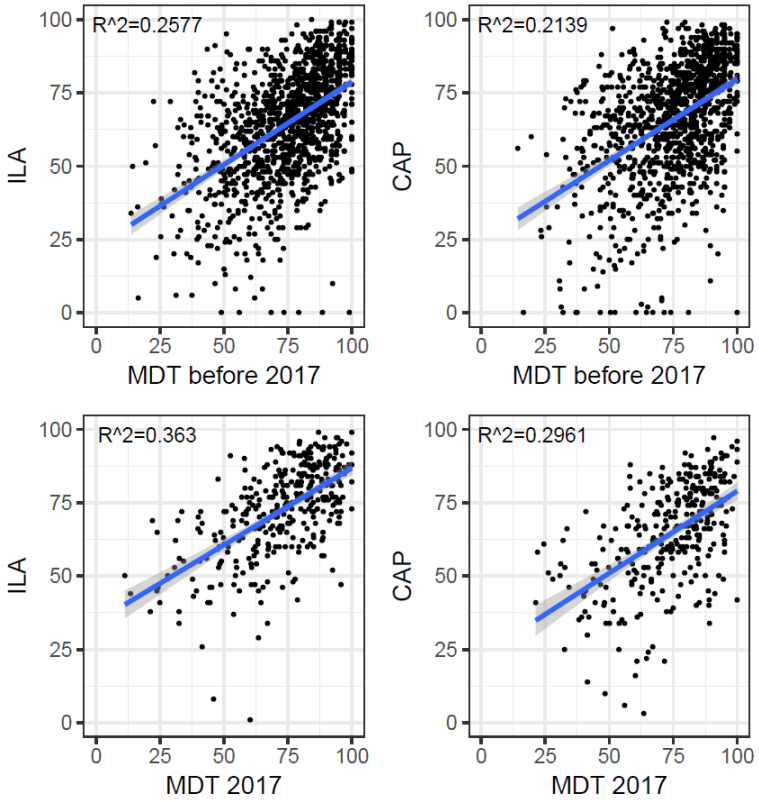
IRT results

- The new test gives more information about ability
- The information is better at higher abilities



Predictive validity

- The new test is also a better predictor of success in Year 1 mathematics
  - Introduction to Linear Algebra (Semester 1)
  - Calculus and its Applications (Semester 2)



Conclusion

- Item response theory can be a useful tool when evaluating the performance of a test
- Removing poorly-performing questions makes the test better!

Thank you!

Acknowledgements

- Statistical analysis was carried out by project students:
  Chito Wang, Tereza Burgetova and Joanne Ruth Imanuel
- The project was funded by the Principal's Teaching Award Scheme at the University of Edinburgh

THE UNIVERSITY of EDINBURGH
School of Mathematics