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# Factors that influence post-16 participation in mathematics and physics

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**To identify range of factors (individual, school and out-of-school, including home) that influence post-16 participation in mathematics & physics**

**To assess the relative importance of such factors among different student populations**

- **What attracts some students?**
- **Why do some students reject these subjects even if they are good at them?**
- **How might we engage more students in these subjects?**

# Structure of Project



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## **Strand 1: Mapping trajectories of engagement and disenchantment**

**A longitudinal design: survey on 20,000 12/13 year-old & 14/15 yr old students in 140 UK schools & followed up eighteen months later**

## **Strand 2: Investigating subjectivities and school culture**

**Interview and ethnography-based study (6-12 schools)**

## **Strand 3: Documenting the reasons for HE choices**

**<sup>3</sup>Narrative work with 50 first-year University Students**

# STRAND 1 SAMPLE



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**Sample of approximately 20,000 students in two year groups (aged 12-13 & 14-15) for whom we have collected data in England, Wales, Scotland and Ireland**

**For this presentation, two core datasets from England**

- survey responses (student & school) year 10 students (aged 14-15)

one mathematics, one physics

**Current multi-level models**

- 1881 students in 63 schools (physics)
- <sub>4</sub> 2384 students in 75 schools (mathematics)

# UPMAP instruments

## *The student questionnaire*

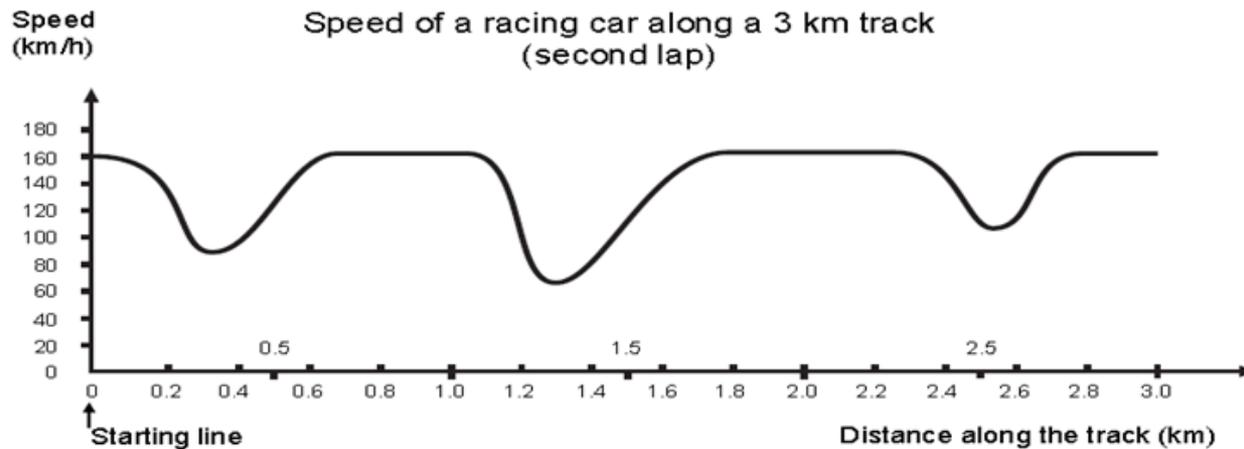


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## Core Content Items (Mathematics)

### R1. RACING CAR

This graph shows how the speed of a racing car varies along a flat 3 kilometre track during its second lap.



a) What is the approximate distance from the starting time to the beginning of the longest straight section of the track?

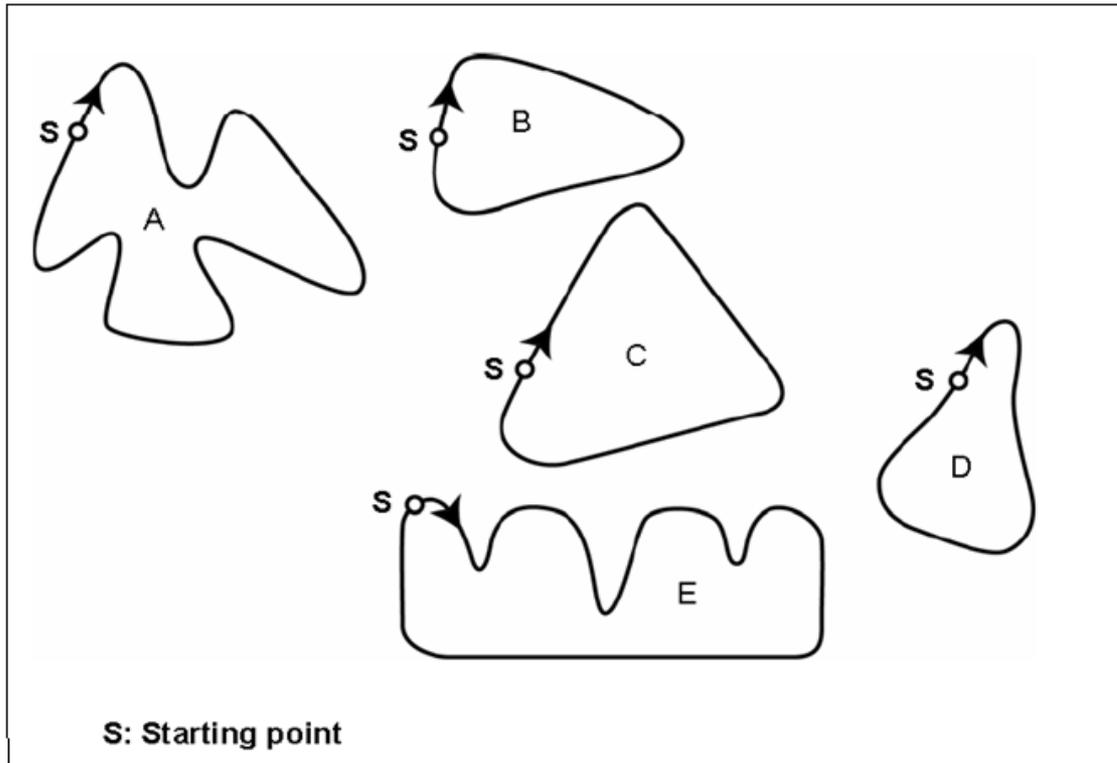
- 0.5 km       1.5 km       2.3 km       2.6 km

b) Where was the lowest speed recorded during the second lap?

## Core Content Items (Mathematics)

d) Along which one of these tracks was the car driven to produce the speed graph shown earlier?

**A**  **B**  **C**  **D**  **E**

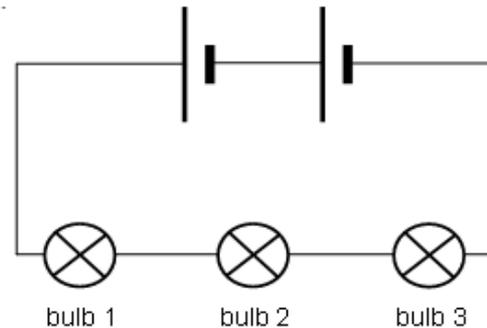


e) How confident are you that your answers to the Racing Car questions are correct?

## Core Content Items (Physics – Y8)

### E1. ELECTRICITY 1

The three bulbs in this circuit are identical.



(a) How bright will the bulbs be? Put a cross  in ONE box only.

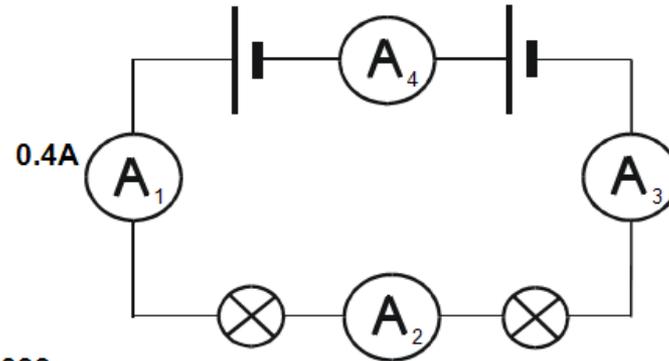
- |  |                          |
|--|--------------------------|
| Bulb 1 is lit. The others are off.                       | <input type="checkbox"/> |
| Bulb 3 is lit. The others are off.                       | <input type="checkbox"/> |
| Bulbs 1 and 3 are bright. Bulb 2 is dimmer.              | <input type="checkbox"/> |
| Bulbs 1 and 3 are dim. Bulb 2 is brighter.               | <input type="checkbox"/> |
| Bulb 1 is brightest, then bulb 2, and bulb 3 is dimmest. | <input type="checkbox"/> |
| Bulb 3 is brightest, then bulb 2, and bulb 1 is dimmest. | <input type="checkbox"/> |
| All the bulbs are lit with the same brightness.          | <input type="checkbox"/> |

(b) How would you explain the result you indicated in part (a)? Put an  in ONE box only.

## Core Content Items (Physics – Y10)

### E1. ELECTRICITY 1

In this circuit below, the reading on ammeter  $A_1$  is 0.4 amps.



What reading you would expect to see ....

(a) .. on ammeter  $A_2$ ?

Put a cross  in ONE box

- More than 0.4A
- Exactly 0.4A
- Less than 0.4A, but not zero
- Zero

(b) .. on ammeter  $A_3$ ?

Put a cross  in ONE box

- More than 0.4A
- Exactly 0.4A
- Less than 0.4A, but not zero
- Zero

(c) .. on ammeter  $A_4$ ?

Put a cross  in ONE box

- More than 0.4A
- Exactly 0.4A
- Less than 0.4A, but not zero
- Zero

		Construct	N of items
Self concept	Physics	.821	12
	Maths		
Advice pressure to study	Physics	.853	5
	Maths	.839	
Intrinsic value	Physics	.801	7
	Maths	.758	
Extrinsic value	Physics	.863	9
	Maths	.776	
Attitude to and perceptions of math/physics lessons	Physics	.592	5
	Maths	.582	
Perception of teachers	Physics	.858	14
	Maths	.845	
Sense of school belonging	Physics	.828	6
	Maths	.840	
Emotional stability	Physics	.700	6
	Maths	.708	
Competitiveness	Physics	.707	9
	Maths	.727	
Introversion	Physics	.604	4
	Maths	.618	
Home support for achievement	Physics	.621	8
	Maths	.602	
Home support for achievement in general	Physics	.852	3
	Maths	.892	
Relationship with parents	Physics	.743	4
	Maths	.783	
Engagement with ICT	Physics	.575	6
	Maths	.609	
Social support	Physics	.637	6
	Maths	.611	
Global Motivation & aspiration	Physics	.733	4
	Maths	.710	



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# UPMAP instruments – the school questionnaire

<b>Description of item/ CORE CONSTRUCT</b>	<b>From questionnaire</b>
Extent of informal & formal internal collaboration	<b>Item F19 (QUAL)</b> <b>Item G1 (SA)</b> <b>Item G4(SA)</b>
Number of students taking post 16 maths & physics courses	<b>Item F 23 (SA)</b> <b>Item 24 (SA)</b>
Awareness of the issues of post-16 engagement	<b>Item E 1- 3, 5 (QUAL)</b> <b>Item 6 (QUANT)</b> <b>Item F 20 (SA)</b>
Engaged in enrichment activities to promote post-16 engagement	<b>Item B2 (QUANT)</b> <b>Item E 4 (QUANT &amp; QUAL)</b> <b>Item B 1a (SA)</b> <b>Item B 1b (QUAL)</b>
Schools with policies that promote continuation	<b>Item F 21(SA)</b> <b>Item 22 (QUAL)</b> <b>Item 26,29,28, 27, 30,31a (QUAL)</b> <b>Item C30, C31 (QUANT)</b> <b>Item G2- G3 (QUANT)</b>
Schools that value mathematics & physics teachers (CPD)	<b>Item C 10 (SA)</b> <b>**Item F 6,7 (QUANT)</b> <b>Item I 1- 9 (QUANT)</b> <b>Item G5 (SA)</b>
Schools that ensure good careers advice are in place	<b>Item H 1-3 (QUANT)</b>
Schools with adequate and stable mathematics & physics staffing	<b>Item C 1-3, 11, (QUANT)</b> <b>**Item F 8, 9(QUANT)</b> <b>Item F 17 (SA)</b>
Priorities of maths & physics department	<b>Item F 14 (SA)</b> <b>Item F 14 (QUAL)</b> <b>Item F 15,</b> <b>Item 16 (SA)</b> <b>Item 18 (QUAL)</b>
How schools deploy maths & physics staffing	<b>Item F 1 (SA)</b> <b>Item F2 (QUAL)</b> <b>Item F3-5 (QUANT)</b> <b>**Item F8-9 (QUANT)</b> <b>Item F10 (QUAL)</b> <b>Item F11 (QUAL)</b> <b>Item F12 (QUAL)</b>
Explore whether schools have adequate mathematics & physics resource	<b>Item C 4-9. 11. 12</b>
Qualitative approach of schools with adequate mathematics & physics resource	<b>Item D (QUAL)</b> <b>Item F 13 (SA)</b>
Background information on the teacher who filled in the questionnaire	<b>Item A1-A9</b>

## **Student survey data is matched to the**

- National Student Database (NPD)
- Student Level Annual School Census (PLASC)
- school survey responses.

## **PLASC & NPD datasets hold information on**

- students' attainment records at age 7 and 11
- background details on students such as gender, eligibility for free school meals, ethnicity.

# Student characteristics

	Mathematics Year 10	Physics Year 10
	%	%
<b>Year the students expect to take GCSE</b>		
9	0.5	0.9
10	24.8	36.8
11	74.7	62.2
<b>Whether the student intends to continue studies after age 16</b>		
Yes	94.3	93.7
No	5.7	6.3
<b>Ethnicity</b>		
White UK heritage	63.1	83.4
Any Black	1.4	2.2
Any Asian, Bangladeshi, group	2.8	4.0
Chinese	0.0	0.0
Indian	3.0	2.8
Black and White mixed	0.4	0.7
White and Asian mixed	0.7	0.8
Other	0.0	6.1
<b>Gender</b>		
Female	54.0	44.7
Male	46.0	55.3
<b>FSM</b>		
No FSM	94.5	94.8
FSM	5.5	5.2
<b>No. of Siblings</b>		
1	50.9	49.3
2	31.3	29.2
3	12.9	11.9
4+	5.0	9.3
<b>Fathers SES</b>		
Professional	33.3	33.2
Clerical and skilled non-manual	10.5	11.0
Senior official	4.4	6.2
Store worker	3.4	2.9
Skilled manual worker	27.2	28.2
Semi-skilled manual	2.7	2.3
Unskilled worker	4.9	4.3
Homemaker	0.7	0.8
Don't know	9.5	8.1
Unemployed	3.4	3.1
<b>Mothers SES</b>		
Professional	31.3	33.6
Clerical and skilled non-manual	22.6	22.6
Senior official	1.4	1.5
Store worker	6.4	5.6
Skilled manual worker	3.4	3.8
Semi-skilled manual	8.9	8.7
Unskilled worker	3.6	3.5
Homemaker	11.3	11.2
Don't know	6.1	5.6
Unemployed	5.0	3.8

# Characteristics of schools

	Year 10 sample
	%
<b>Segmentation by attainment &amp; participation rate of school</b>	
High attainment, high staying-on	44.9
High attainment, average staying-on	15.8
High attainment, low staying-on	5.8
Low attainment, high staying-on	5.9
Low attainment, average staying-on	13.0
Low attainment, low staying-on	14.6
<b>Segmentation by mathematics &amp; physics participation rate of school</b>	
High maths, low physics	4.1
Low maths, high physics	2.1
Low maths, low physics	19.8
Average maths, average physics	22.4
High maths, high physics	51.7
<b>Admission policy of the school</b>	
Comprehensive	82.0
Selective	14.8
Modern	3.2
<b>Gender of the school</b>	
Boys	9.8
Girls	21.0
Mixed	69.2

# Intention to Participate in mathematics and physics



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- **More students reported that they *were not* intending to study physics post-16 compared to those that were.**
- **More students reported that they *were* intending to study mathematics post-16 compared to those that reported they were not.**
- **In physics strong agreement in intention to participate is just over three times as likely amongst boys than girls.**
- **For mathematics the gender bias in intention to participate was not as large as the differences seen in physics.**

# Gender: mathematics & physics conceptual scores



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- **PHYSICS:** More girls than boys score high (8+) in physics conceptual questions (10.2% versus 7.6% of boys) though girls were less confident, (15% versus 32% of boys) had no confidence.
- **MATHEMATICS:** More boys than girls score 5 (high mark) on the conceptual score (31% versus 18.7% of girls).
- In total 17.6% of girls reported having no confidence compared to 7.7% percent of boys. Similarly 33.3 percent of girls were highly confident (score of 3) compared to 55.4% of boys.

## **Positive statistically significant ( $p < 0.01$ ) correlations with intentions to participate post-16 in mathematics & physics**

- **students' self concept in mathematics & physics**
- **family, teacher and peer pressure to study**
- **students' global motivations and aspirations**
- **student organizational skills**
- **attainment at age 11 in mathematics & science**
- **home support of study in general & subject specific**
- **intrinsic reasons**
- **extrinsic reasons**

## Core differences between mathematics and physics multilevel participation models

### School variables

- Engagement in external projects (for mathematics not physics)
- Specialist teachers (for physics not mathematics) & only at KS3 (age 13/14)

### Student variables

- Males were on average more likely to express an intention to participate in both subjects post-16, though in the physics model gender lost significance after controlling for some key school level influences.
- Attainment (for mathematics not physics).
- Indian heritage (for mathematics not physics).
- 19 Perception of mathematics (for mathematics not physics).

## Core similarities between mathematics and physics multilevel participation models

- **Students' extrinsic motivation**
- **Confidence in conceptual tasks**
- **Subject-specific self concept**

## Examples of items

	<b>Student item</b>	<b>School/teacher item</b>
<b>Perception of mathematics lessons</b>	<i>When I am doing maths I always know what I am doing</i>	
<b>Self concept</b>	<i>I look forward to maths/physics lessons</i>	
<b>Confidence in conceptual tasks</b>	<i>How confident are you that your answer to part (b) is correct</i>	
<b>Extrinsic motivation</b>	<i>People who are good at maths/physics get well paid jobs</i>	
<b>Adequate resources</b>		<i>Shortage or inadequacy of teaching material</i>

## Variance at student and school level.

- **The physics model without explanatory variables: 90% of all variation in the outcome is at the student level & 10% at the school level.**
- **The mathematics model without explanatory variables: 92.56% of all variation in the outcome is at the student level & 7.43% at the school level.**
- **The Physics final model to date: The final model explains 91% of all variance at the school level & 35% of all variance at the student level.**
- **The Mathematics final model to date: The final model explains 77% of all variance at the school level & 30% of all variance at the student level**

exploring the outcome variable attainment at age 11

- **Students socio-economic status (FSM & IDACI)**
- **Black heritage less likely to state an intention to participate in physics. For attainment we found those of Asian heritage, Black heritage, other heritage and Indian heritage were less likely to do well.**
- **Competitiveness predictor of attainment (physics only) not participation (either subject).**
- **Score in conceptual tasks (attainment not participation).**
- **Confidence in conceptual tasks (both attainment & participation).**
- **The self concept (both attainment & participation).**

## Implications

- Perhaps conceptual ability is confounded in some way with school level measures and thus cause the non significant result between conceptual tasks and intention to participate.
  - Research to tease out differing relationships in explaining intention and attainment & their inter-relationship – in strand 2 & next survey (in one year)
  - Why is having specialist teachers more important at KS3 than at KS4?
  - Perhaps schools are better at eradicating differences in intention to study between different SES groups:- school influences need to be tailored more towards bridging the gap between intention to participate and actual ability.
- 24 Differential effects between schools?

## Variation between Schools

Schools' residual classification	Physics		Mathematics	
	n	%	n	%
Significant positive *	1	1.58	1	1.33
Positive/not significant but within the expected range	30	47.61	43	57.33
Negative/not significant but within the expected range	32	50.79	27	36.00
Significant negative*	0	0.00	4	5.33

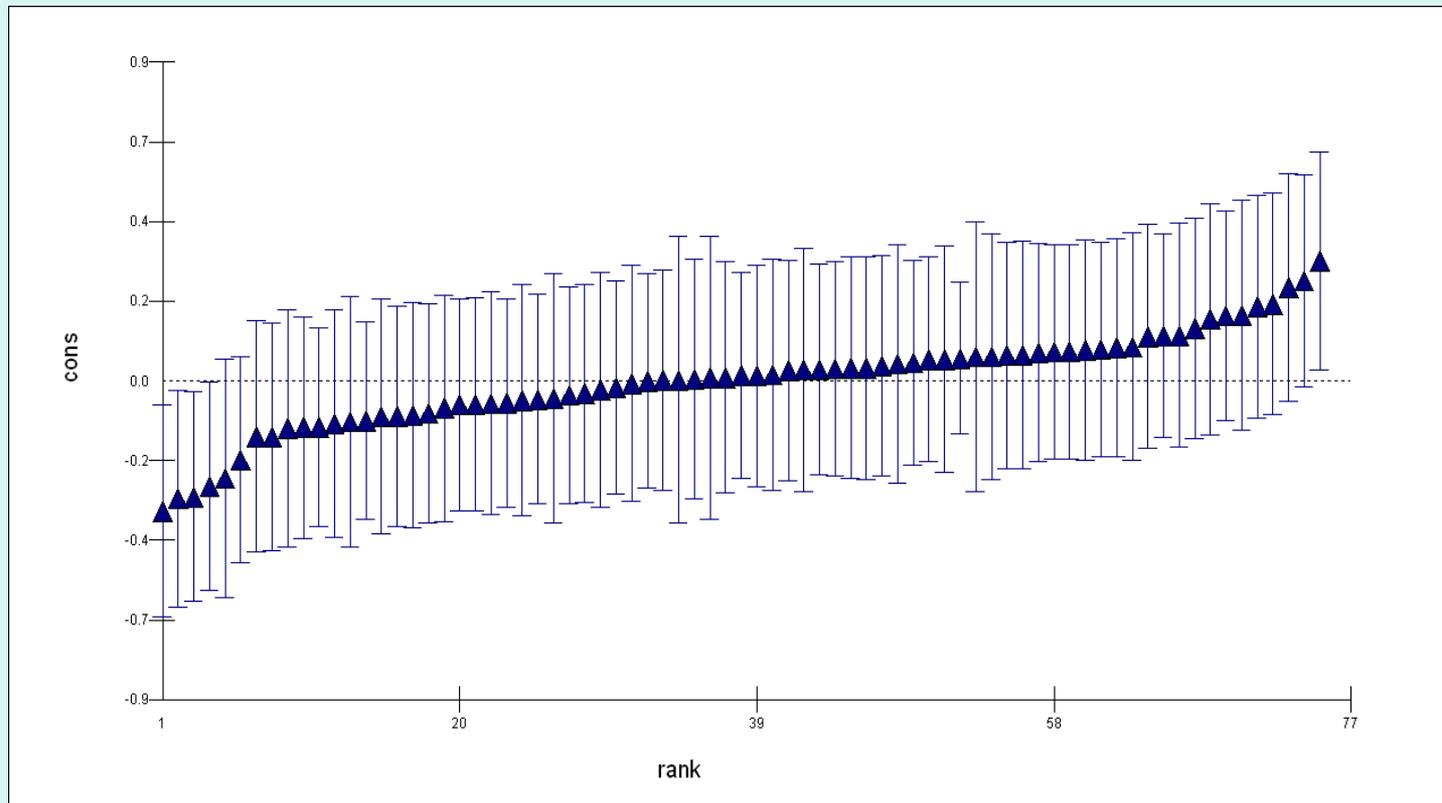
\*  $p < 0.05$

# Multi-level analysis

## Mathematics outlier schools



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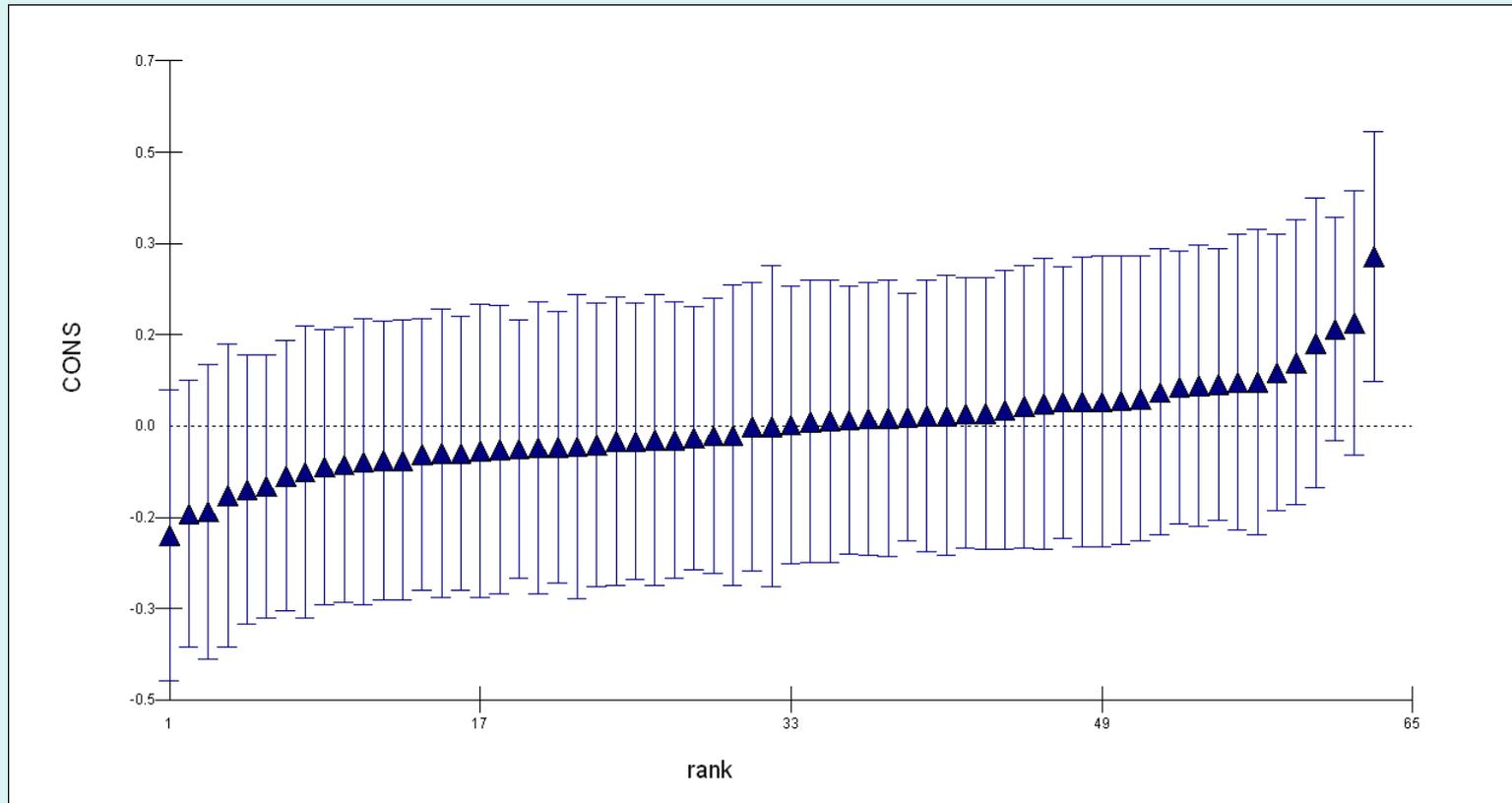


# Multi-level analysis

## Physics outlier school



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# Multi-level analysis

## Mathematics outlier school



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- **75-100% classes contain specialist mathematics teachers at KS3 & KS4**
- **Non selective, mixed above post-16 progression rate**
- **Engages in external collaboration**
- **Teachers had good opportunities for CPD**
- **The school was good at ensuring career advice**
- **Fair amount of enrichment activities for students**
- **Stable staffing**
- **Good resources to teach mathematics**

# Qualitative work beginnings of triangulation



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## Jane

- **A shy, introvert 15 yr girl, loves physics, wants to study post 16 mathematics & physics**
- **The school was a mixed gender, high ability, high physics participation school in an affluent area, that selects on ability tests at age 10-11.**
- **Not typical examples of why physics practicals interesting.**
- **Needed to study mathematics for access to career path**
- **Studying physics because she liked it & was engaged.**
- **Family influences to study physics (early age).**

# For further information on UPMAP



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