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Factors that influence post-16 participation in mathematics and physics

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Abstract

This paper presents the preliminary findings from analyses of responses from a sample of student and school questionnaires that together explore the factors that shape student engagement with mathematics and physics and their choices for further study post-16. Our preliminary results are derived from multi-level analyses of two core datasets put together from various sources of information for year 10 students (aged 14-15) in schools in England. The sample on which we undertook analyses comprised 1881 students in 63 schools (physics) and 2384 students in 75 secondary schools (mathematics). The results presented here on are based on a sub-sample of approximately 20,000 students in one year groups (aged 14-15) from data collected in England.

The paper utilizes multi-level modeling methods in order to ascertain which school and student level indicators have an independent influence in explaining students' intention to participate in mathematics and physics post-16. Our interim results indicate that the students' self concept in mathematics & physics and extrinsic motivation, are key psychological factors that have an independent influence on uptake of physics and mathematics post-16. Other important factors appear to be students ethnic and gender background as well as their understanding of core mathematics & physics concepts, although both failed to reach significance in our final models. This data also suggests that found that school policy plays an important role in reducing gender biases and in general for all student groups, increasing the intention to participate in mathematics and physics. Our multi-level analysis indicates that after controlling for the impact of school policy on physics specialist classes and school selection indicated this was useful in helping reduce gender biases in participation and ensuring a more advantageous learning environment for females. For mathematics engagement in external projects had an impact on student intention to participate in post-16 mathematics. Our initial findings also indicate that boys are more likely to have increased motivations in their intention to participate in high attaining high participation schools, more so than girls.

We also conducted a comparative multi-level analysis on science and mathematics attainment which indicates that there seems to be different forces in play that explain difference between motivation to study these subjects post-16 and actual attainment. In the interim period between now and April 2010 we will conduct further research to tease out differing relationships that come to play in explaining motivations and attainment and of course their inter-relationship. This paper begins to explore ideas for which we will build upon in order to explore issues around differential effects of school influence on student participation.

Section 1: **Introduction and setting the scene**

This paper discusses a survey into the factors that influence post-16 participation in physics in the UK, carried out as part of the Understanding Participation in Mathematics and Physics (UPMAP) project. The aim of the UPMAP project (funded by the ESRC) is to identify through systematic research using a mixture of qualitative and quantitative methods the interrelation of these factors, taking account of differences between schools as well as between individuals. Policies that aim to increase participation in mathematics and physics will only be successful if they are based on an understanding of factors that influence participation in post-16 physics and mathematics.

The study is one of key importance in the current educational climate of Europe, where there are an increasing number of government initiatives to raise attainment in mathematics and science and a growing acknowledgement that there is a problem in post-compulsory participation rates in them, particularly in industrialised countries (Gilbert, 2006; OECD, 2006). These initiatives have been triggered by economic concerns about the implications of a deepening shortage of scientists and mathematicians along with a shortage of specialist teachers in these two domains. Our study concentrates more specifically on physics, in part because the problems are more severe and in part because of the close links between physics and mathematics (cf. Carson, 1999). In addition, the profile of student participation in physics and mathematics is similar, as is the shortage of specialist teachers.

Much remains to be done to understand what determines student attitudes towards mathematics and science (Osborne *et al.*, 2003) and what drives student subject choice post-16 (Blenkinsop *et al.*, 2006). Our research draws on what is known about student attitudes and extends this by considering the extent to which mathematics and physics, and school mathematics and school physics, are meaningful to students. Our understanding of meaningful includes what is often, in the literature, described as relevance but we also, more fundamentally, examine the extent to which knowledge needs to connect (cf. Zohar, 2006) with a learner's life and cohere with notions of developing personal identity. When students encounter school mathematics and physics, they can respond to these discourses in a variety of ways (Mendick, 2006). This can help make sense of the widespread phenomenon in which many of those who do well in mathematics and the sciences reject them (Reiss, 2005). Our work, therefore, is grounded in the principle that students respond to curricula, to pedagogies and to subject representations outside of schools by partial negotiations, both between themselves and the subject. Unless there is sufficient positive connect between a student's developing sense of self and the meanings they find in mathematics / physics, the student-subject relationship may not flourish but atrophy or become one of antagonism.

Section 2: **Methods**

The data were collected in two inter-related strands, using a mixture of qualitative and quantitative methods.

Strand 1 maps trajectories of engagement and disenchantment by analyses of large scale and longitudinal statistical data that encompass engagement with core areas of knowledge as well as attitude and perceptions of physics and mathematics. Employing a longitudinal design, these questionnaires are intended to be completed by approximately 100 12/13 year-old and 100 14/15 year-old students (in the upper two-thirds of the attainment range) in each of 100 or more UK schools in the academic year 2008/09 and again by the many of the same students eighteen months later.

Strand 2 investigates subjectivities and school culture by focusing in on schools that have various progression rates in physics and maths in order to ascertain reasons for variations in progression rates. In section 8 of this paper we briefly touch upon the beginnings of our analysis in this area.

UPMAP Instruments

The student questionnaire

Student questionnaires' were designed following a comprehensive review of the literature considering factors that may influence participation rates in mathematics and physics. It includes items to assess attitudes to the subject, the school and teachers, alongside more general potential influences on participation, such social capital, engagement in extra-curricular activities, intrinsic and extrinsic motivation for learning, involvement in ICT, personality constructs and family support of studying physics. In addition, we include two items in what we term core conceptual areas in mathematics and physics in order to assess attainment and confidence. The research instruments were piloted in 5 schools with approximately 800 students. Feedback from students and their teachers helped to illuminate the contexts, inside and outside of school, which helped or hindered post-16 participation in the two subjects. We used the pilot phase to decide the final set of items to be used based on qualitative feedback from students and internal reliability of the questionnaire constructs.

Table 2.1: The student questionnaire constructs

Construct	Subject	Cronbach's alpha	N of items
Self concept	Physics	.821	12
	Maths	.811	
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	

Please refer to http://www.ioe.ac.uk/study/departments/gems/4814.html for links to the full set of instruments.

The school questionnaire

Two 'school questionnaire' was also constructed to be completed by the heads of the science and mathematics departments. These aim to assess each department's policies in relation to promoting post-16 participation in mathematics physics, the expertise of their staff and how they are deployed, activities to boost engagement in the subject through, for example, extra-curricular activities, and practices in relation to student groups and examination entries. These are summarised in table 2.2. We are yet to finalise these constructs and we are still testing different clumps of questions together in our final multi-level models.

Table 2.2: *The school questionnaire constructs*

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

Please refer to http://www.ioe.ac.uk/study/departments/gems/4814.html for links to the full set of instruments.

The Current UPMAP Dataset

In order to explore these over aching research questions we made use of England's National Student Database (NPD) and Student Level Annual School Census (PLASC) by matching records onto our survey data. These datasets were given to the team by the Department for Children Schools & Families (DCSF). We currently have a vast amount of information and the results here report on some of this data. The PLASC & NPD datasets hold information on students' attainment records at age 7 and 11, as well as various background details on students such as gender, eligibility for free school meals and ethnicity.

We have also collected, via our own school questionnaire and via the PLASC data, information on individual schools and we hope that, through further analysis in 18 months time, we will be able to explore the impact of within-school variation on students' intention to participate. Initial decisions have been made about the way in which to group students and variables for our first attempt at running our models.

The data were set up as such that a high score represents strong agreement in intention to participate.

Tables 3.1 and 3.2 give an overview of the characteristics for the year 10 groups in our dataset.

Table 3.1: Characteristics of students with valid year 10 data

	Mathematics Year 10	Physics Year 10
	%	%
Year the students expect to take GCSE		
9	0.5	0.9
10	24.8	36.8
11	74.7	62.2
Whether the student intends to continue studies after age 16		
Yes	94.3	93.7
No	5.7	6.3
Ethnicity		
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
Gender		
Female	54.0	44.7
Male	46.0	55.3
FSM		
No FSM	94.5	94.8
FSM	5.5	5.2
No. of Siblings		
1	50.9	49.3
2	31.3	29.2
3	12.9	11.9
4+	5.0	9.3
Fathers SES		
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
Mothers SES		
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

Table 3.2: Characteristics of our schools included in the analysis (for the Year 10 group/sample)

	Year 10 sample (%)
Segmentation by attainment & participation rate of school	
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
Segmentation by mathematics & physics participation rate of school	
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
Admission policy of the school	
Comprehensive	82.0
Selective	14.8
Modern	3.2
Gender of the school	
Boys	9.8
Girls	21.0
Mixed	69.2

Section 4: The influence of gender on mathematics and physics participation and conceptual competence

Intention to Participate in mathematics and physics

Our preliminary findings, as shown in table 4.1 (which only reports for the year 10 groups), with regards to the relationship between intention to participate and gender are consistent with general patterns of participation reported in many studies within the UK. The general trends in participation indicate that students are more likely to express an interest in studying mathematics post 16 than physics. These findings even cut across the genders, with both sexes in general expressing more of an interest in studying mathematics post-16 than physics.

- In general more students reported that they *were not* intending on studying physics post 16 (42.3 were in strong disagreement or disagreement with not studying physics compared to 22.1 % who were in agreement or strong agreement with studying physics).
- In general more students reported that they *were* intending on studying mathematics post 16 (24.9% were in strong disagreement or disagreement with not studying mathematics compared to 42.6% who were in agreement or strong agreement with studying mathematics).
- In physics strong agreement in intention to participate is just over three times as likely amongst boys than girls.
- For maths the gender bias in intention to participate was not as large as the differences seen in physics.

Table 4.1: Intention to Participate in Physics post-16 and gender (year 10)

		Responses					
Subject	Sample	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
Physics	Overall	19.1	23.2	13.0	18.6	13.8	8.3
	Boys	15.6	18.2	13.5	19.8	19.7	15.2
	Girls	23.6	29.1	13.6	19.0	10.0	4.8
Maths	Overall	10.7	14.2	10.7	21.9	24.3	18.3
	Boys	9.0	10.6	9.0	20.3	28.3	22.8
	Girls	12.2	17.1	12.1	23.2	20.9	14.5

Ability in conceptual tasks and gender

We have identified from the literature, and from expertise within our own team, diagnostic questions in mathematics and physics that can reflect students' overall understanding of core concepts within these subjects. Research indicates that students who do not understand such concepts lose confidence and motivation. Such conceptual tests were included within our survey instrument which comprised items in maths for algebra and number. Some of these were in open format and required written calculated responses some multiple-choice. In physics, we had a set of conceptual tasks that looked at students' level of understanding of ideas related to forces and electricity. Although the items were derived from previous research that had already established the validity of these items (Hoyles, 2006), we piloted the conceptual tasks in the context of our main survey in five schools in Summer 2008.

Physics

More girls than boys score 8+ on the total physics conceptual items/tasks (10.2% versus 7.6%). In contrast to their actual ability in the conceptual tasks, girls were less confident. Around a third of girls reported having no confidence in getting the conceptual tasks correct compared to only 15 percent of boys. Correspondingly, around 15 percent of girls were highly confident (score of 4) compared to just over a third of boys.

Table 4.2: Physics Year 10 conceptual task total score

	Overall total	**Boys total**	**Girls total**
.00	1.8	2.0	1.7
1.00	6.1	6.5	5.5
2.00	13.8	15.1	12.7
3.00	19.4	19.7	19.1
4.00	15.1	15.0	15.4
5.00	9.9	9.5	10.3
6.00	11.5	11.1	11.9
7.00	13.5	13.6	13.2
8.00	5.8	4.8	6.7
9.00	2.3	2.0	2.7
10.00	.6	.6	.7
11.00	.1	.1	.1
12.00	.0	.1	

Table 4.3: Physics Year 10 confidence in conceptual tasks

	Overall total	Boys total	Girls total
0 (no confidence)	24.7	15.3	32.2
1 (low confidence)	17.5	12.4	21.6
2	17.4	16.3	18.2
3	16.6	21.2	13.0
4 (high confidence)	23.9	34.8	15.0

Mathematics

- More boys than girls score 5 (high mark) on the maths conceptual score (31% versus 18.7%).
- In terms of the questions that explored students' confidence in their ability to do the conceptual tasks, girls were less confident. In total 17.6% of girls reported having no confidence in getting the conceptual tasks correct compared to 7.7% percent of boys. Similarly 33.3% of girls were highly confident (score of 3) compared to 55.4% of boys.

Comparison between mathematics and physics

- Although the findings of the gender differentials between the physics and the mathematics tasks appear to be counterintuitive, (with more girls scoring higher on physics tests) a direct comparison should not be made at this stage nor any preliminary conclusions reached, as the mathematics conceptual score is based on only one of our task measures. Secondly the physics and mathematics conceptual task results are based on tests coded and assessed using very different methods. In our final analysis once we have the data on the measurement of maths conceptual task competency, we will be able to make more direct and valid comparisons as we will convert both the physics and maths scores into the same type of scale.

- Similar to the findings within physics confidence questions, boys were more confident than girls.

Mathematics

Table 4.3: Mathematics Year 10 Conceptual task total score

	Overall total (%)	**Boys total (%)**	**Girls total (%)**
.00	2.0	2.4	1.6
.50	1.1	1.3	.9
.75	.2	.3	.1
1.00	4.7	3.9	5.4
1.50	2.1	1.4	2.6
1.75	.7	.6	.8
2.00	11.1	9.3	12.6
2.50	6.5	4.8	7.9
2.75	2.0	1.7	2.4
3.00	17.0	15.4	18.4
3.50	11.3	8.2	13.7
3.75	3.7	4.0	3.3
4.00	13.5	15.6	11.7
5.00	24.3	31.0	18.7

Table 4.4: Mathematics Year 10 confidence in conceptual tasks

	Overall total	**Boys total**	**Girls total**
0 (no confidence)	13.0	7.7	17.6
1 (low confidence)	18.5	13.1	20.6
2	22.8	23.7	28.6
3 (high confidence)	45.7	55.4	33.3

Section 5: **Correlations**

At the time of submission, survey and attainment data have been collected from approximately 90 out of the 200 schools and thus the findings reported in it are partial and preliminary. In order to explore our research questions we made use of England's National Student Database (NPD) and Student Level Annual School Census (PLASC) by matching records onto our survey data. These datasets were given to the team by the DCSF (Department for Children Schools & Families). We currently have a vast amount of information and the results here report on some of this data. The PLASC & NPD datasets hold information on students' attainment records at age 7 and 11, as well as various background details on students such as gender, eligibility for free school meals, ethnicity.

Bi-Variate analysis

- **Physics:** Significant positive ($p<0.01$) correlations (Pearson's Product) between students' intention to study physics post-16 and the following were found: students' self concept in physics (.507); family, teacher and peer pressure to study physics (.383); students' global motivations and aspirations (.489); organizational skills (.479); physics attainment at age 11 (.084); home support of study in general (.038); and of physics in particular (.243); intrinsic reasons for studying physics (.388); extrinsic reasons for studying physics (.528).

- **Mathematics:** Significant positive ($p<0.01$) correlations (Pearson's Product) between the intention to study mathematics post-16 and the following were found: conceptual competence (.174) students' self concept in mathematics (.497); family, teacher and peer pressure to study physics (.515); students' global motivations and aspirations (.267; intrinsic reasons for studying mathematics (.479); extrinsic reasons for studying mathematics (.330); mathematics attainment at age 11 (.448); home support of study in general (.130); and of mathematics in particular (.295).

Mathematics		**Physics**	
family, teacher and peer pressure to study physics	.515	extrinsic reasons for studying physics	.528
students' self concept in mathematics	.497	students' self concept in physics	.507
intrinsic reasons for studying mathematics	.479	students' global motivations and aspirations	.489
mathematics attainment at age 11	.448	their organizational skills	.479
extrinsic reasons for studying mathematics	.330	intrinsic reasons for studying physics	.388
home support of study of mathematics in particular	.295	family, teacher and peer pressure to study physics	.383
students' global motivations and aspirations	.267	home support of study of physics in particular	.243
conceptual competence	.174	physics attainment at age 11	.084
home support of study in general	.130	home support of study in general	.038

Section 6: **Multi-level analysis: The influence of gender on mathematics and physics participation and conceptual competence**

Our preliminary results from the sophisticated multi-level analysis presented here is derived from the analysis of two core datasets that we put together from various sources of information for year 10 students (aged 14-15) in schools in England. The current final multi-level models put forward to explain participation based on 1881 students in 63 schools for physics and 2384 students in 75 secondary schools for maths. The analysis did begin with a larger number of schools and students but due to missing information, as the analysis progressed, the sample size was reduced. In September 2009 we will be sent the data on missing students and therefore increasing our sample size on these preliminary findings. In addition we will have received our final file that will contain the full set of survey data, which will hold responses of approximately 20,000 students in schools in England, Wales, Northern Ireland and Scotland. This final set of data will also contain survey responses from year 8 or equivalent (aged 12-13) students.

Whilst other techniques are also able to give us the individual estimate of the impact of each predictor after controlling for all the other predictors in the model, multi-level modeling techniques recognize the hierarchical nature of student and are able to look at the impact of both individual student level variables and the impact of school level variables on students intention to participate. Our preliminary findings were interesting and promising although we are treating these as first stage iterative findings that we will build on.

The main aims for conducting the multi-level analysis

- To assess the relationships between students' background factors such as socio-economic background (eligibility for free school meals), ethnicity, age and are deprivation (IDACI score) and their intention to participate in mathematics post 16
- To identify any particular student groups who may be less likely to participate.
- To assess the relationship between school ethos and students participation in mathematics/physics post 16
- To assess the interaction between school ethos variables and student level variables

Initial thoughts on findings at the school level for both mathematics and physics

Amongst school-level variables, there were very few that were statistically significant and even less so that had significant interaction effects with gender, particularly for mathematics. However a key point to note here is that the models tested so far did not look at the variability of particular effects e.g. the differential effect of schools for high ability girls in single sex schools. We will explore differential effects once we have finalized our core student level predictors in the larger sample. For either subject, there were no significant interaction effects between school level variables with ethnicity and with FSM (a measure of socio-economic status disadvantage; SES).

School ethos was an umbrella term that covered; engagement in enrichment activities, engagement in CPD, ensuring good careers advice and adequate and stable staffing. This construct, considered as a school-level predictor, was tested either alone or as an interaction effect with gender, did not appear to be related to intended participation trends. It is too early to suggest that none of these factors have an impact on intended participation as these are our preliminary findings based on a partial dataset and initial exploration.

Our treatment of school level variables will continue to try new and alternative ways of collapsing, combining or re-coding these variables in order to explore effects. We were particularly interested in the mathematics of physics ethos of the school and how this related to participation. Our current way of testing for ethos involved combining answers from engagement in enrichment activities, engagement in CPD, schools that ensure good careers advice and schools with adequate staffing and resources.

The following school level predictors were also found not to be significantly related to intention to participate post-16:

Mathematics: School mathematics ethos; school mathematics ethos* gender; participation trends of the school (although was initially significant); adequate resources (this was not significant after controlling for involvement in external projects); school attainment level at age 16 (categorized as high, medium, low); school type (selective on ability, single sex schools, non selective mixed schools).

Physics: School physics ethos; school physics ethos* gender; participation trends of the school; adequate resources; school attainment level at age 16 (categorized as high, medium, low; school type (selective on ability single sex schools versus non selective mixed schools). Interestingly having physics specialist teachers at KS4 (age 15-16 classes) did not appear to have any influence on students intention to participate in physics BUT having more specialists in place at KS3 (age 14-15 year old students), did appear to have an influence.

Core differences between mathematics and physics participation

i. The differences in intention to participate in mathematics were larger for males (than females) between schools that engaged in external projects compared to those that did not. To date, engagement in external projects has not been found to have an influence on physics participation.
ii. As expected, being a part of a high attainment high physics participation school had a positive impact on a students motivation to want to participate (including a significant interaction term with gender), although no such relationships were found with mathematics.
iii. Males were, on average, more likely to express an intention to participate in both subjects post 16. Although in the physics model gender was not significant after controlling for

some key school level influences (schools participation & attainment rate post-16 and academic selection of school).

iv. Mathematics attainment at age 11 appears to be a significant predictor of intention to participate as measured at the age of 15, whereas No such relationship was detected between science attainment at age 11 and intention to participate in physics. This difference is perhaps related to the fact that the science measure was not explicitly only measuring physics attainment. In our further analysis we will look at age 14 scores in physics and how that relates to intended participation.

v. Being of Indian heritage (compared to White heritage) was a significant predictor of intention to study mathematics. No significant ethnic effects were found in our physics model.

vi. Perception of mathematics lessons at age 15 was related to intention to participate in mathematics post 16. This was not a significant predictor for physics.

vii. Teachers' perceptions of whether the resources they had were adequate for teaching, was not significant (just failed significance) in the mathematics participation model but the results did indicate that the gender bias diminished in schools where resources were not an issue. This requires further exploration. No relationship was found reported with intention to study physics.

viii. Exploring for use of physics specialist classes and school selection indicated that these was useful in helping reduce gender biases and that indeed females were more advantaged. Our initial findings also indicate that boys are more likely to be impacted in their motivation to want to study physics post 16 depending on whether they are in schools with no selection or some selection (schools that select on ability). No such findings were reported with mathematics.

ix. We found that for physics, but not mathematics, having specialist teachers was important in influencing students' intention to participate. Again the other nteresting, finding is that this only has an influence if this is applicable at the beginning of secondary school education (age 11) rather than at the age of 15.

Core similarities between mathematics and physics findings

x. Students' extrinsic motivation in studying either subject was related to intention to participate

xi. Confidence in conceptual tasks was equally predictive of intention to study either subject post 16.

xii. Subject specific self concept was related to intention to study.

Item 6.1: Examples of items from some of our constructs that were found to have an influence on participation

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

Mathematics & Physics Model A: Multi-level analysis: exploring the outcome variable intention to participate in

Model findings: The key advantage of our multilevel models is that they recognize that our students' responses are within a data set that come from a common source, (each of their schools). Student and school observations are in general not independent and it is important to model this dependency. Our models explore students intention to participate in physics post 16 (and later we also look at attainment) and we have partitioned the 'overall variation' into variation between and variation within the schools. A summary of the importance of schools in explaining the proportion of the total variance accounted for is termed the intra class correlation.

i. **The Physics null model:** The estimated parameters are not fixed or conditional on other effects in the model as this model does not contain any explanatory variables, at any level. This model was computed in order to predict the intention to participate, based on an intercept term and error terms with no predictor factors or covariates (ethnicity, sex, FSM). Although the statistics are not reported here, a key purpose of our null models & continuous testing of further models, were mainly used to obtain baseline -2LL (loglikihood estimates), that we used to measure improvements in our final models as we added or took away explanatory variables at both the student or school level. Prior to accounting for the impact of explanatory variables on intention to participate, the overall mean of intending to participate in physics was 2.9 (range 1-6) and that for different schools were distributed about their overall mean with a variance of 10% (the intra class correlation) and thus indicating that 90% of all variation in the outcome is at the student level (between students or within schools). The results obtained also gave estimates of 2.6% for the between schools variance thus also highlighting that there is a clustering effect (that students within similar schools are perhaps responding similarly).

   The Mathematics null model: 7.43% of all variation in the outcome is at the school level (or between schools) and 92.56% of all variation in the outcome is at the student level (or between students or within schools).

ii. **The Physics final model to date:** The final model that we are currently putting forward to explain intention to participate in physics post-16 found that the intra class correlation reduced to 1.44%, (the proportion of total variance explained that is at the school level which was originally 10% before accounting for any school level or student level factors). This finding although not of core interest to the reporting of the final model, do indicate to UPMAP that explanatory variables put forward have usefully explained and accounted for differences in intended participation rates, between schools. The final model explains 91% of all variance at the school level (which was reported at 10% in the null model). The final model explains 35% of all variance at the student level (within schools or between students) of the original 90 percent of variance.

   The Mathematics final model to date: The final model explains 77% of all variance at the school level (which was reported at 7.43% in the null model). The final model explains 30% of all variance at the student level (within schools or between students) of the original 92.56 percent of variance.

Physics Model B: Multi-level analysis: exploring the outcome variable physics attainment at age 11

Using the same datasets we additionally started to explore factors that are associated with physics attainment at age 11. This was measured by an overall 'Science' score, taken in national assessment tests in England. UPMAP found some interesting differences between this final model and the model that explored intention to participate in physics post 16.

- Students' socio-economic status as measured by FSM was initially a significant predictor of attainment (although failed significance once other measures were put in). This predictor did not have any impact in explaining physics participation.
- Neighbourhood deprivation of students did not explain their intention to participate in physics or mathematics. Although the relationship with attainment was significant and large, indicating that those from more poor neighbourhoods were less likely to attain well in national science tests.
- Those of Black heritage (compared to White heritage) were less likely to state an intention to participate in physics. No other ethnic group differences were found to be significant. In our model that explained science attainment, we found those of Asian heritage, Black heritage, and Indian heritage were less likely to do well in science attainment, compared to students of White heritage.
- Engagement with ICT did not explain their intention to participate in physics but did explain science attainment. The results suggest that those that are more engaged in ICT (at age 15) were less likely to do well in science age 11 tests.
- As we report below with mathematics, competence in physics conceptual tasks at age 15 was related to physics attainment at age 11 although this lost significance in explaining participation once we examined school level predictors.
- The majority of our personality constructs in general in our preliminary testing of attainment and intention to participate, were not significant. A few though did indicate some interesting results.
    - The physics self concept at age 15 was a positive predictor of attainment at age 11 and intention to participate at age 15, although the estimate was slightly bigger in explaining attainment.
    - Being competitive at age 15 was a positive predictor of attainment at age 11 although it was not a significant predictor of intention to participate in physics.
    - Confidence in conceptual tasks was related to both attainment and intended participation in physics.

Mathematics Model B: Multi-level analysis: exploring the outcome variable mathematics attainment at age 11

Using the same datasets we additionally started to explore factors that are associated with mathematics attainment at age 11. This was measured by an overall 'mathematics' score, taken in national assessment tests in England. Similar to the findings with physics, UPMAP found some interesting differences between this final model and the model that explored intention to participate in mathematics post 16.

- Students' socio-economic status as measured by FSM was a significant predictor of mathematics attainment (although failed significance once other measures were put in). This predictor did not have any impact in explaining mathematics participation.
- Neighborhood deprivation of students did not explain their intention to participate in physics or mathematics. Although the relationship with mathematics attainment was significant and large, indicating that those from more poor neighbourhoods were less likely to attain well in national science tests.
- Engagement with ICT did not explain their intention to participate in mathematics but did explain science attainment but not mathematics attainment. The results suggest that those that are more engaged in ICT (at age 15) were less likely to do well in science age 11 tests but has no influence on mathematics.
- As with the physics, competence in maths conceptual tasks at age 15 was related to maths attainment at age 11 although this lost significance in explaining participation once we examined school level predictors.
- The majority of our personality constructs in general in our preliminary testing of attainment and intention to participate, were not significant. A few though did indicate some interesting results.
    - The mathematics self concept at age 15 was a positive predictor of mathematics attainment at age 11 and intention to participate at age 15. Both of these findings were established with the two physics models (attainment and participation).
    - Confidence in conceptual tasks was related to both attainment and intended participation in mathematics.

Table 6.1: Multi-level analysis Student and school level factors

	Background factors	**Intention to study Mathematics at post 16 Year 10 students**	**Maths achievement**	**Intention to study Physics at post 16 Year 10 students**	**Science achievement**
Student level factors					
Student background characteristics	**Gender [female] male**	+	n/s	n/s	+
	Ethnicity [E/S/W]				
	Black	n/s	n/s	-	-
	Asian (FN)	n/s	n/s	n/s	-
	Indian	+	n/s	n/s	-
	Mixed race heritage groups	n/s	n/s	n/s	n/s
	Other	n/s	-	n/s	n/s
	FSM [no FSM	n/s	-	n/s	n/s
	Age in months at time of survey	-	Not relevant	-	Not relevant
	Measure of home neighbourhood deprivation	$	-	$	-
Students' perceptions	**Intrinsic motivation**	$	n/s	$	$
	Extrinsic motivation	+	n/s	+	$
	Perceptions of maths OR physics lessons	+		$	$
	Maths OR physics self concept	+	n/s	+	+
	Confidence in conceptual tasks	+	Not tested	+	Not tested
	Competitiveness	$	$	+	$
Measures of attainment	**Total in conceptual task score**	$	+	n/s	+
	Maths OR science test at age 11	+	Not relevant	n/s	Not relevant
School level factors					Not relevant
	Adequate resources	+	Not relevant		Not relevant
Interaction terms	**Schools with adequate and stable maths Resources or Staffing*gender [female]** **male**	n/s	Not relevant	$	Not relevant
	Involvement with external projects *	-	Not relevant	$	Not relevant

	gender	-			
Academic selection (no selection)	**Some selection** **Full selection**	$	Not relevant	+ n/s	
Type of school based on attainment & participation rates * gender (low attainment & low staying on rates post-16)	**Low attainment & average staying on rates in physics post 16**	$	Not relevant		
% of classes taught by physics specialists (0-24% of classes taught by specialists)	**25-49% classes** **50-74% classes** **75-100% classes**	$	Not relevant	- - -	

Physics= range of students per school 1-93, total n of students approximately 1881, N of schools in each analysis 63
Mathematics= range of students per school 1-51, total n of students approximately 2384, total n of schools = 75
$= tested, not significant & removed
n/s= in the final model but not significant
+ = significant positive effect
- = significant negative effect

Section 7: **Variation between schools in students' motivation to participate in mathematics and physics**

In order to establish whether some schools had students whose motivation levels in intention to participate were above or below what would be predicted on the basis of their students' intake characteristics, further analyses were conducted for each school and we obtained a residual measure for each school. Each model controlled for students socio-economic background, ethnic background, age and gender. A residual measure (based on the difference between students' actual participation scores and those predicted on the basis of contextualized intake) was calculated for each school.

The residuals are quite small in magnitude as is the case with any analysis conducted using multi level methods. Shrinkage occurs with residuals for methodological reasons. Within our datasets (as with many educational datasets) there will be some schools with only a very few students that form part of our final analysis and in such instances we have relatively little information about the school. UPMAP's estimate of that school's performance is the overall mean. Using traditional ANOVA methods would have provided us with imprecise estimates (with large standard errors thus leading to the conclusion that an effect is not significant when really it is) and so instead of using this imprecise mean on its own, our multilevel models have used the information that any individual school is a member of the population of schools whose parameters have been estimated from the data, by using a weighted combination of the estimated population mean and the estimated school mean. This method then involves shrinking the observed school mean (for any given school) towards the centre of the school population.

With educational data of the kind that UPMAP has analysed, both in terms of modeling attainment patterns and participation trends, the level 2 (school) residual measures can also be termed school effects. The pattern of results for all schools in our participation models are shown below.

The analysis of school' results shown in Table 7.1 can be summarised as follows:

- For physics, 1 out of 63 schools (1.58%) were identified as having significantly positive residuals and 0 were identified as having significantly negative residuals.

- For mathematics, 1 out of 71 (1.33%) schools were identified as having significantly positive residuals and 4 (5.33%) were identified as having significantly negative residuals.

Table 7.1: Summary of schools' contextualised results in terms of positive and negative residuals for Physics & Mathematics

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

Physics = n of students in each analysis approximately xxx N of schools in each analysis 63
Mathematics = range of students per school 1-51, total n of students = 2384, total n of schools = 75

Having calculated the school residuals we inspected them in several ways using graphicular plots in order to check model assumptions of normality. The plot 7.1 below shows the ranked residuals plotted against corresponding points on a normal distribution curve and the straight line indicates that the normality assumption is valid thus giving us more confidence in both of our final physics and mathematics participation model.

Figure 7.1: Graphicular plots in order to check model assumptions of normality

Physics: The ranked residuals

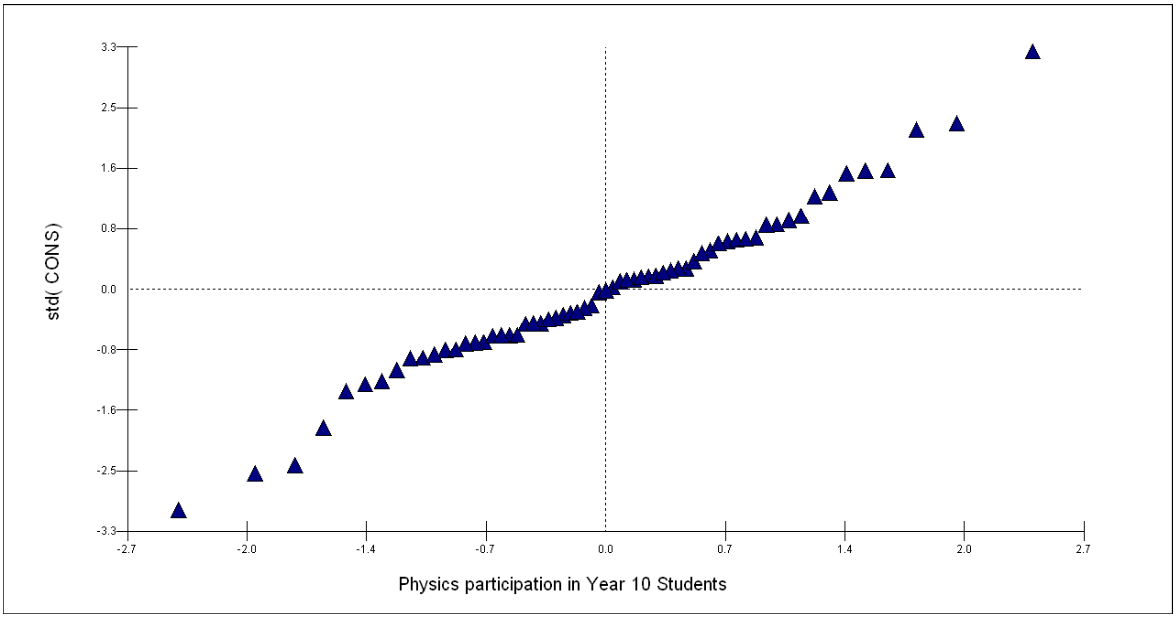
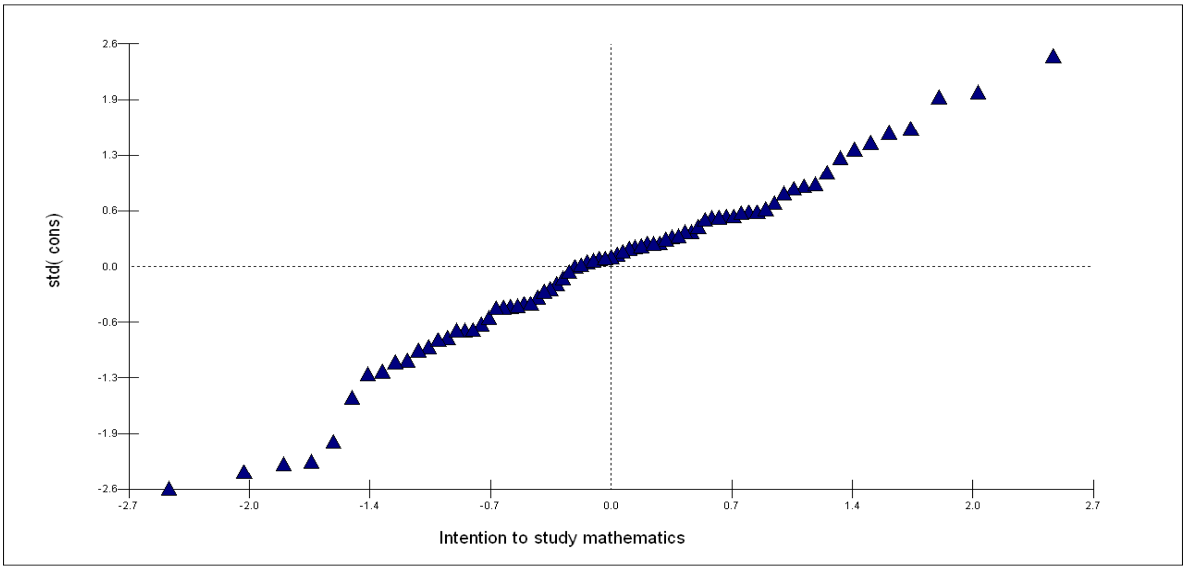


Figure 7.2: **Mathematics: The ranked residuals**



Physics and mathematics outlier schools

Although the findings of both the models and residuals presented to date are interim results, nonetheless we are interested in specific outlier schools and any such schools that are in the positive or negative range of residuals, as further exploration of such schools will help shape our qualitative work, even if such schools are not part of our overall case study schools (12 in total). For the purpose of this conference we will sketch details on the one school that was our significantly positive physics outlier school.

The caterpillar plots display the individual schools residuals with their 95% confidence intervals in ascending order. For physics we have 63 school level residuals plotted each representing our final 63 schools and for mathematics we have 75 schools plotted in a similar fashion. By inspecting the confidence intervals the UPMAP physics participation analysis indicates that there is only one school at the upper end of the plot where the confidence interval for its residuals does not overlap zero and that this schools residual is significantly different from the average at the 5% level. For mathematics we have 1 significant positive outlier school and 4 significant negative outlier schools.

Examination of outlier schools in detail will help flag up or at least point to some core fundamental differences that will help illuminate why students in some schools are more or less likely to participate in mathematics and physics post 16.

Figure 7.3: **Physics caterpillar plot**

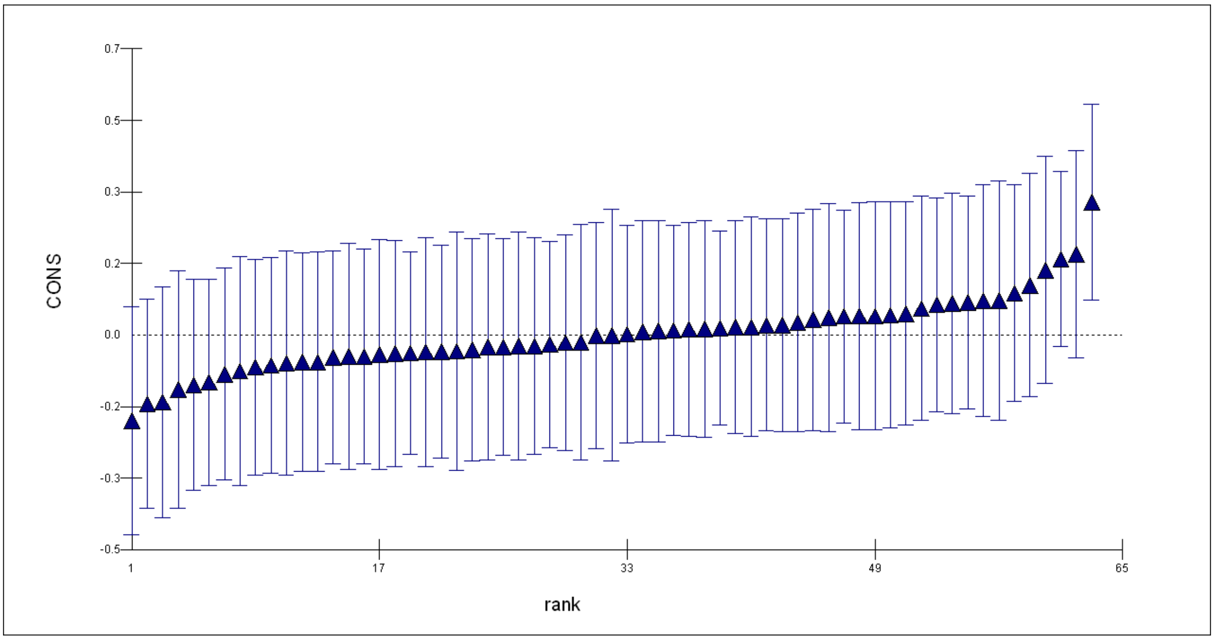
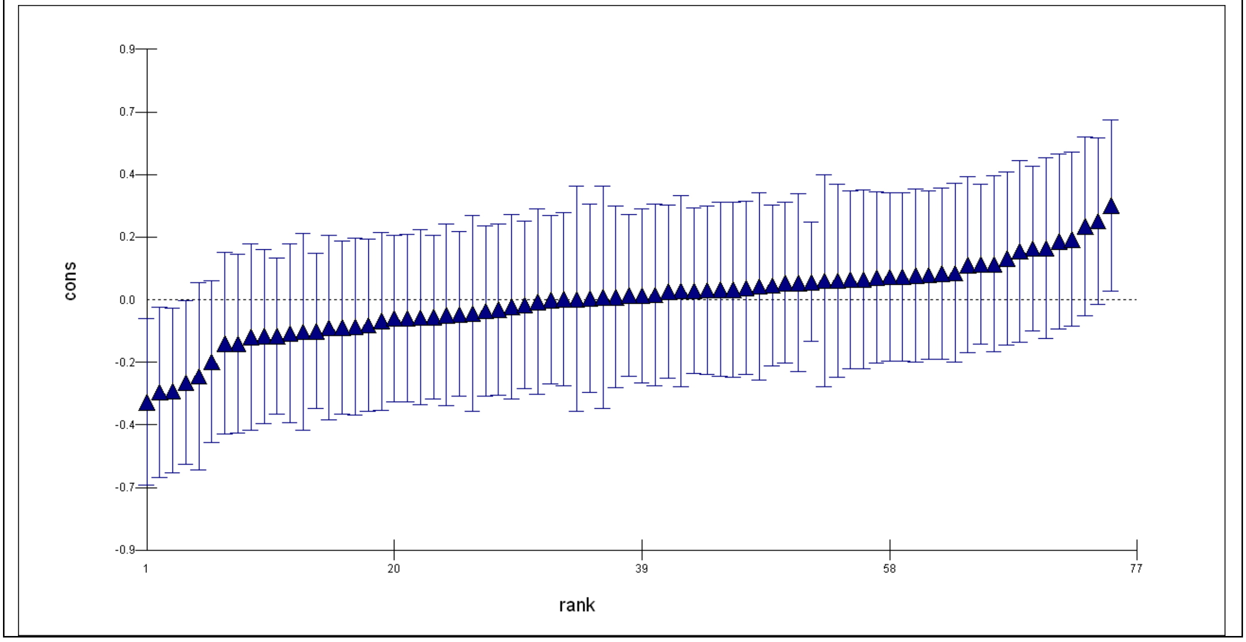


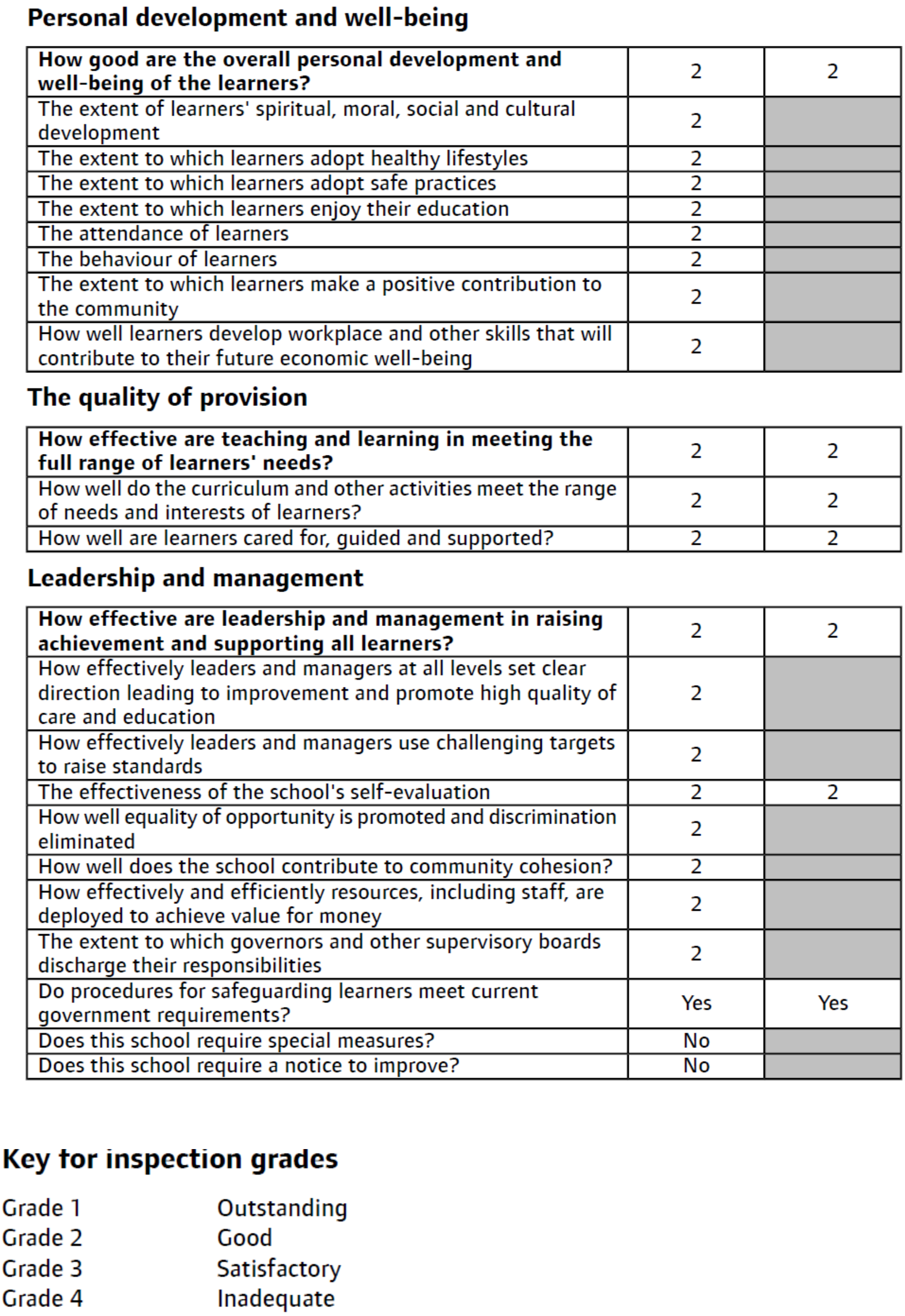
Figure 7.4: **Mathematics caterpillar plot**



An example of the significant positive Physics outlier school

The school is a mixed, 11-18, non-denominational school with a special science status based in County Durham. The school has held specialist science status since 2003 and the Science Learning Centre North East is located at the school. High Performing Specialist School status was awarded in 2008. The school has had Training School status since 2004. It is an above average sized secondary school situated on the northern outskirts of the city. In recent times the demographic changes have meant that much more students now come from outside the school's normal catchment area. What is particularly interesting is that a number of students choose to travel some distance in order to attend this school. In terms of ethnic heritage, most of the students are from White British backgrounds and very few have English language problems. The number of students in receipt of free school meals are lower than average. Although the proportion of students with learning difficulties and/or disabilities is in line with national averages, the proportion of students with statements of special educational needs is below the national England average. The school was inspected and judged by Englands OFSTED inspectors in 2008. In general the results were exemplary. Figure 7.5 below shows some of the results from OFSTED. An exploration of publically available data as well as further interrogation of data based on particular schools will help illuminate issues surrounding the impact of school policies and school ethos on its relationship with participation.

Figure 7.5: Physics outlier school from multi-level analysis: 2008 OFSTED judgement



Personal development and well-being

How good are the overall personal development and well-being of the learners?	2	2
The extent of learners' spiritual, moral, social and cultural development	2	
The extent to which learners adopt healthy lifestyles	2	
The extent to which learners adopt safe practices	2	
The extent to which learners enjoy their education	2	
The attendance of learners	2	
The behaviour of learners	2	
The extent to which learners make a positive contribution to the community	2	
How well learners develop workplace and other skills that will contribute to their future economic well-being	2	

The quality of provision

How effective are teaching and learning in meeting the full range of learners' needs?	2	2
How well do the curriculum and other activities meet the range of needs and interests of learners?	2	2
How well are learners cared for, guided and supported?	2	2

Leadership and management

How effective are leadership and management in raising achievement and supporting all learners?	2	2
How effectively leaders and managers at all levels set clear direction leading to improvement and promote high quality of care and education	2	
How effectively leaders and managers use challenging targets to raise standards	2	
The effectiveness of the school's self-evaluation	2	2
How well equality of opportunity is promoted and discrimination eliminated	2	
How well does the school contribute to community cohesion?	2	
How effectively and efficiently resources, including staff, are deployed to achieve value for money	2	
The extent to which governors and other supervisory boards discharge their responsibilities	2	
Do procedures for safeguarding learners meet current government requirements?	Yes	Yes
Does this school require special measures?	No	
Does this school require a notice to improve?	No	

Key for inspection grades

Grade 1	Outstanding
Grade 2	Good
Grade 3	Satisfactory
Grade 4	Inadequate

Table 7.2 summarises some of the data that we collected from the UPMAP school survey for each of our positive physics and mathematics outlier schools. The table indicates some interesting findings. It is interesting to see that for mathematics our outlier school, in 2007, was classified as a low attainment (at age 16 exams) and low staying on rates post-16 in mathematics & physics. The data we have conducted our analysis on is on year 10 (age 15) students, so it is likely that changes put into place within the school &/or the mathematics department, are motivating this cohort of students in wanting to study mathematics post 16. We will have data on 2008 & later 2009 'attainment & post-16 participation rates' and we will track whether over the years the school has changed categories. As expected both schools were high scoring on various dimensions that are perhaps related to students' intentions and motivations such as; being engaged in external collaboration, supportive of teachers CPD, ensuring good careers advice for students, engagement in enrichment activities and stable staffing.

Table 7.2: Summary of our two significant outlier schools in mathematics & physics

Our two positive outlier schools	**Maths**	**Physics**
Percentage of KS3 classes (early secondary school) with specialist teachers	75-100% classes contain specialist mathematics teachers	0-24% classes contain specialist mathematics teachers
Percentage of KS4 classes (late secondary school) with specialist teachers	75-100% classes contain specialist mathematics teachers	50-75% classes contain specialist mathematics teachers
Does this school pick on academic achievement?	No selection	No selection
Progression rate on to post 16 subjects within the school	Above average	Above average
Whether the school is involved in external collaboration related to mathematics and physics	Yes	Yes
Whether the school is single sex or mixed sex	Mixed school	Mixed school
Type of school	Comprehensive	Comprehensive
Total score of questions that compute whether the resources are adequate to teach mathematics or physics	18 (score is in the mid range)	24 (score is in the high range)
Total score for engagement in CPD (for teachers)	38 (score is in the high range)	32 (score is in the mid-high range)
Whether the school ensures good careers advice	12 (score is in the high range)	12 (score is in the high range)
Ethos and engagement in enrichment activities	20 (score is in the mid range)	31 (score is in the high range)
Whether the school has stable and adequate staffing	8 (score is in the high range)	9 (score is in the high range)
Average attainment of students in this school at the age 16 exams, combined with their staying on rates in maths and physics post 16 (based on 2007 data).	Low attainment at age 16 exams and low staying on rates post-16 in maths & physics	High at 16 attainment and average staying on rates post-16 in maths & physics

Section 8: **Qualitative work for illustrations & beginnings of triangulation**

Some 140 schools have participated in our main phase survey work with 12 of these schools agreeing to be in our case study sample (in Strand 2). To date we have interviewed 65 students in order to explore issues around subject choices and we are in the process of analyzing the transcripts. We will follow up these students in January 2010 and therefore have a longitudinal dimension to the interview work and thus later be able triangulate findings from the quantitative strand 1 work and the longitudinal findings from the qualitative strand 2 work and enabling UPMAP to focus on the implications identified for post-16 participation in physics. The analysis we have currently begun on strand 2 indicates that there are interesting cases that go against the grain.

A preliminary finding is that of Jane. A shy, introvert 15 year old girl, who loves physics, wants to study it post 16, unlike the females interviewed at her school or as the findings suggest in strand 1. 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. Jane, typically like many students interviewed she described the memorable and interesting part of physics as being 'when we put what we learnt into practice, because it tests whether you actually learnt it or not', although her reason for why she found it interesting was not typical. In general, both males and females within her school and across the board in the study named the practical part of experiments because they were 'fun'. Her description of physics and maths was illuminated with interesting examples, she was engaged with both subjects and her deep interest in the two came across well. The core difference that came across in her wanting to study mathematics and physics was that she needed to study mathematics in order to access her chosen career path whereas with physics her liking and strong 'bond' with physics came across quite strongly. In comparison the interview revealed her engagement with English (as UPMAPs comparison subject) was less enthusiastic. Her lack of engagement with English could have been in part due to a constant exposure to supply teachers. Although Jane's relationship with physics is not typical of females in general or amongst her peers, her response to a set of questions that tested students' perceptions of a person who was good at maths, revealed that she too held stereotypical views of being successful in maths as being associated with being male.

In summary we find that the factors that are related to her wanting to study physics post-16 are largely to do with family influences, personality characteristics and ability in physics whereas for mathematics it was more to do with accessing a chosen career.

Further thoughts and future analysis

So far our analysis has been concerned with the influence of student-level factors and school level factors on the influence of students' participation. We have done some exploration of differences between females and males, although such analysis is still in its embryonic stages. Previous research in both the British and cross Atlantic school effectiveness studies have pointed to the effectiveness of a school being differential, with departments having individual effects and indeed that schools may not be equally effective for all student groups, whether that is for different ability levels, gender, socio-economic status or ethnic backgrounds eg (Sammons et al., 1997). The analysis presented so far is based on approximately 20% of our final sample. Once we are able to firmly explore and establish student and school effects on participation and further explore student level factors that impact participation, UPMAP will move into the direction of replicating ideas based on school effectiveness models but this time by taking it in the direction of differential influences on intended participation in mathematics and physics.

Our analysis to date is tentative and school level factors and departmental level effects have not been entirely explored, nor separated out or indeed the inter-relationship between student level factors. Although we say in our paper that to date no school ethos effects were found, this may be due to the way in which we coded variables and tested our hypothesis in our models. We are **not** therefore concluding that school ethos does not have an independent influence on participation.

We had initially hypothesized that student level variables that have often found to have an independent and strong influence on academic attainment, would also have an impact on intention to participate. Recent research indicates that the effect size of such background variables is quite large even after controlling for a range of other student and school level factors (Sammons et al. 2008). Rather surprisingly both of our year 10 physics and mathematics multi-level analysis indicated that SES had no influence on intention to participate, though there was a strong gender effect. We tested for SES using both the student level simple dichotomous measure of FSM (yes or no) and by the more sophisticated IDACI score, a measure of neighbourhood deprivation (a score at the grouped neighbourhood level rather than at the individual student level). A testing to previous research on attainment, we found that both FSM & IDACI score measure of SES had a strong and independent influence on academic attainment at age 11. So what do these findings indicate for our research? It may be the case that influences at the school level, eradicate differences in motivations between different SES groups to study mathematics and physics and that school influences need to be tailored more towards bridging the gap between intention to participate and actual ability. We will be further exploring issues surrounding school policy on encouraging post-16 uptake. We will collect further data in some 12 months time, where we will track our current sample of students and collect data on what they finally had decided to study. It will be at this point where we will be able to further explore issues between intention to study, actual study, school influences, SES and actual attainment.

Conclusions and Implications

The preliminary findings from an analysis of a sample of student questionnaires regarding the factors that shape their engagement with physics and choices for further study indicate that the students' subject specific self concept and extrinsic motivation, are key psychological factors that have an independent influence on uptake of physics post-16. Other important factors are students ethnic and gender background as well as their understanding of core physics and mathematic concepts. It is apparent in our analysis that perhaps conceptual ability is confounded in some way with our school level measures and thus cause the non significant result in the relationship between conceptual tasks and intention to participate. This needs further exploration in both the physics and mathematics participation models.

The relationship between intention to participate and gender are consistent with general patterns of participation as reported in many studies within the UK. We also have found that school policy plays an important role in reducing gender biases and in general for all student groups, increasing the intention to participate in physics. The comparative analysis conducted on science and maths attainment indicates that there seems to be different forces in play that explain difference between motivation to study post-16 and actual attainment. Further research to tease out differing relationships that come to play in explaining motivations and attainment and of course their inter-relationship, will continue to take place and build upon the findings to date.

The different models put forward to date to explain mathematics and physics intention to study are in itself illuminating. The differences indicate that policy to boost the two STEM subjects need to be individual, different and targeted. Controlling for the impact of school policy on physics specialist classes and school selection indicated to us that this was useful in helping reduce gender biases and that indeed females were more advantaged. Our initial findings also indicate that boys are more likely to have increased motivations in their intention to participate in high attaining high participation schools, more so than girls. We also found that for physics but not mathematics having specialist teachers was important in influencing students' intention to participate. Again the other interesting finding is that this only has an influence if this is applicable at the beginning of secondary school education (age 11) rather than at the age of 15.

The general trends in participation indicate students are more likely to express an interest in studying mathematics post 16 than physics. These findings even cut across the genders, with both sexes in general expressing more of an interest in studying mathematics post-16 than physics. We intend to explore this issue further within our qualitative interviews. The findings that have been derived to date and the models we will build upon will help UPMAP frame ideas to be explored phase 2 of our case study interviews. The next phase of qualitative interviews will be crucial in bridging the relationship between students learning experiences and relationship with mathematics and physics and how these will in 12 months time relate to subject choices and indeed their attainment (age 16 national assessment examinations). The example we have given of 'Jane' from our phase 1 interview sample, illustrates that many students perceive mathematics as having 'exchange value' whether it is in terms of being seen as 'more clever' or in terms of being able to have a positive influence in getting paid more in their future careers. Certainly these preliminary hypotheses have a firm basis in Human Capital theory which suggests that individuals (and firms) invest in education and training in order to boost earnings and productivity (Becker, 1964). Research indicates that taking mathematics post-16 has a direct impact on future earnings. Over and above the impact of family background, and qualifications students who take advanced math have higher income ten years after graduating, (Rose, 2004).

The synthesized findings from these two strands will allow us to identify and interpret the range of factors, their relative importance and their interactions that influence post-16 participation in mathematics and in physics. Over the course of the next nine months UPMAP will continue to explore in detail the influences of various networks (social & academic) that have differing impacts on students identities as learners of mathematics and physics. This will provide us with a strong evidence base upon which to make recommendations about the kinds of interventions, initiatives and practices that are likely to have the greatest impact on different student groups and thus in raising participation and engagement in mathematics and physics.

Our findings to date point towards recommendations to policy makers to promote and fund interventions, initiatives and practices that will enable students to: increase their positive experiences and confidence with learning in general, as well as with physics/maths in particular;

access extra curriculum support with studying physics and mathematics, when appropriate; and tackle basic misconceptions in core areas of physics and mathematics early on.

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For further information on UPMAP please refer to http://www.ioe.ac.uk/study/departments/gems/4814.html