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Understanding Participation in Mathematics and Physics (UPMAP)

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If Maths were an animal what animal would it be?

A spider because I don’t like them and they’re quite scary.

Something like a dog – it’s loyal, it doesn’t just change, it’s always there.

Context

Student engagement in mathematics and physics –

the reasons for continued participation or non-participation when these subjects become optional.

(Osborne, Simon & Collins, 2003; Blenkinsop et al. 2006).

Students respond to these subjects in different ways – our focus is on their reasons in order to understand why students choose or reject the subjects at the point of choice.

Why do certain students, but not others, choose to continue with their formal studies in mathematics and/or physics post-16?

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Perceptions of self and the subject

Assumptions underpinning the work:

Participation depends in part on how students see both themselves and the subjects.

Perceptions shift as a result of experiences in and out of school (Black, Mendick & Solomon, 2009).

Identification with how meaningful the subject is can result from cultural forces, but an individual's affective response determines their actions.

We investigated the relationships between factors operating at various levels that influence perceptions, identity and actions.

Methodology

The study comprises 3 strands:

Strand 1: quantitative mapping of trajectories of engagement and disenchantment: questionnaire study.

Strand 2: qualitative investigation of students' perceptions and intentions towards physics and mathematics: longitudinal interview study.

Strand 3: qualitative exploration of the reasons for Higher Education choices: narrative interviews

Strand 1 method

Sample of 141 schools across the UK.

Questionnaire for 12-13 year olds and 14-15 year olds, the latter repeated two years later after options chosen post-16.

Validated conceptual tasks to elicit understanding of mathematics and physics.

Validated psychological constructs, e.g. view of the subject, view of achievement in the subject.

Relationships were explored between performance, confidence, and intrinsic and extrinsic factors.

Strand 1 analysis

Multi-level modelling: as a particular instance of multiple analysis of variance in which certain restrictions are placed on the organisation of dependent variables.

Levels:

Individual student

Class/teacher

School

UK region

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Strand 1 findings

Physics:

1749 (709 male and 1040 female) students aged 14-15 were also surveyed at age 16 -17 years.

At age 14, 556 intended not to study physics, 493 to study physics and 700 were undecided.

At age 16, 441 students chose physics, 1,282 chose not to study, and 26 did not give a response.

Strand 1 findings

Those who chose to do physics responded more positively to physics specific constructs:

Self-concept

Perceptions of lessons

Emotional response to lessons

Advice to study physics

Intrinsic motivation in physics

Extrinsic material and social gain motivation

Perceptions of physics teachers

Home support in physics learning

Strand 1 findings

Multi-level modelling showed:

Current conceptual ability and prior attainment were not important in explaining physics participation in the final model once current attainment, extrinsic motivation and family influence were controlled.

Home support for achievement in physics had an influence above and beyond current conceptual ability and prior attainment.

Advice to study physics was related to actual physics take-up.

Encouragement from others both in and out of school was associated with students opting to study physics.

Strand 1 findings

Schools with higher averages in physics attainment were more likely to have students who go on to study physics.

Students choosing to study mathematics post-16 is significantly associated with students studying physics.

Physics self-concept – how students see themselves in relation to the subject has a significant independent relationship with whether or not they choose to study physics post-16.

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Strand 2 method

12 of the Strand 1 schools, in each school:

6 students of above average attainment in each school

One boy and one girl who intend to study mathematics or physics

One boy and one girl who are undecided

One boy and one girl who intend not to study mathematics or physics

These 72 students to be interviewed three times at 15, 16 , 17 years, i.e. studying for age 16 examinations, approaching option choice, post option choice.

Semi-structured interviews to explore students' perceptions, feelings and intentions towards physics and mathematics; the impact of a range of school and personal factors; intentions about the future.

Strand 2 analysis

From the first set of interviews a coding scheme was developed and analysed qualitatively using NVivo. Different analytical themes have been developed from this first set of coded interviews.

Theme 1 - student relationships with mathematics and physics in terms of self-concept and motivation.

Theme 2 - student identification with mathematics and physics in terms of subject ‘personality’.

Strand 2 Theme 1 findings

Students expressed the desire to choose mathematics and/or physics because of the probable external rewards (entrance into Higher Education or careers) they experience as a result of succeeding in these subjects.

Subject choice is derived from a sense of personal empowerment and/or pleasure in being able to do mathematics and/or physics, an empowerment coming from within the individual.

More students had a negative perception of physics than mathematics.

More students held a positive self-concept in mathematics than physics.

Strand 2 Theme 2 findings

Subject personality dimensions set against personality dimensions:

Openness high:

- I like it because it is intellectually stimulating.

- I don't like it because I can't visualise it / it's too abstract.

Openness low:

-I don't like it because it has too little variety / too many facts / I can't express my opinions.

-I like it because it's familiar / dependable / clear cut.

Relevance, agreeableness.

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Strand 3 method

50 students under the age of 21 years in 4 HE institutions.

Half studying physical sciences, technology, engineering or mathematics courses.

Others had the qualifications that would have enabled them to study such courses but had chosen non-STEM courses.

Narrative style interviews – the interviewee is invited to tell their story and is supported by the use of non-directive, positive feedback and questioning.

Feedback from interviewees indicated that the process of talking about ‘their choices’ had brought to mind things they had not been aware of.

Strand 3 analysis

Interpretive analysis drawing on notions from psychoanalysis:

Defence mechanisms : unconscious responses that show how a person defends him/herself.

Splitting: state of mind that splits good and bad – to consider an experience before evaluating it.

Being good enough: what it is to be 'good enough' at mathematics in the context of choosing a STEM subject.

Strand 3 findings

Robin is studying history and economics:

Robin explains that his relationship with teachers influenced his post-16 choices of history and mathematics at school. However, he splits mathematics as 'bad' because:

'*you get told to do this and that's how you do it'.*

For Robin, discarding maths because of loss of 'self' is balanced by finding maths pleasurable in itself (good), but he defends his HE choice due to 'bad' possibilities open to him:

'My ideal would have been history with maths but you can't do that.'

Strand 3 findings

Robin has a mathematical self-identity, yet he was not quite an A* student and his former classmates' abilities are considered superior; so failure is imaginable.

Robin's history teacher inspired hope in a different arena: and Robin follows her path, rather than not be good enough in the STEM world.

Unconscious forces place a greater role in choosing a course of study than may be discovered through survey and semi-structured interview.

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Concluding comments

We found that young people are more likely to continue with mathematics and/or physics after the age of 16:

If they have been encouraged to do so by a key adult (usually in their family or at their school);

if they believe that they will gain from studying the subject in terms of job satisfaction and/or material rewards;

if they can manifest conceptual understanding in the subject(s);

and if they have been well taught.

UPMAP papers

Reiss et al (2011) Understanding participation rates in post-16 mathematics and physics: conceptualising and operationalising the UPMAP project. *International Journal of Science and Mathematics Education* 9(2) 273-302.

Mujtaba, T. & Reiss, M. What sort of girl wants to study physics after the age of 16? Findings from a large-scale UK survey. In press with *IJSE*.

Riazi-Farzad, B., Simon, S. & Reiss, M. 'Maths is loyal like a dog, but English is slimy like a snake': Students imbue school subjects with personalities. Under Review.

Rodd, M., Mujtaba, T. & Reiss, M. Revealing unconscious motivation: undergraduates talk about participation in STEM post 18. Under review.