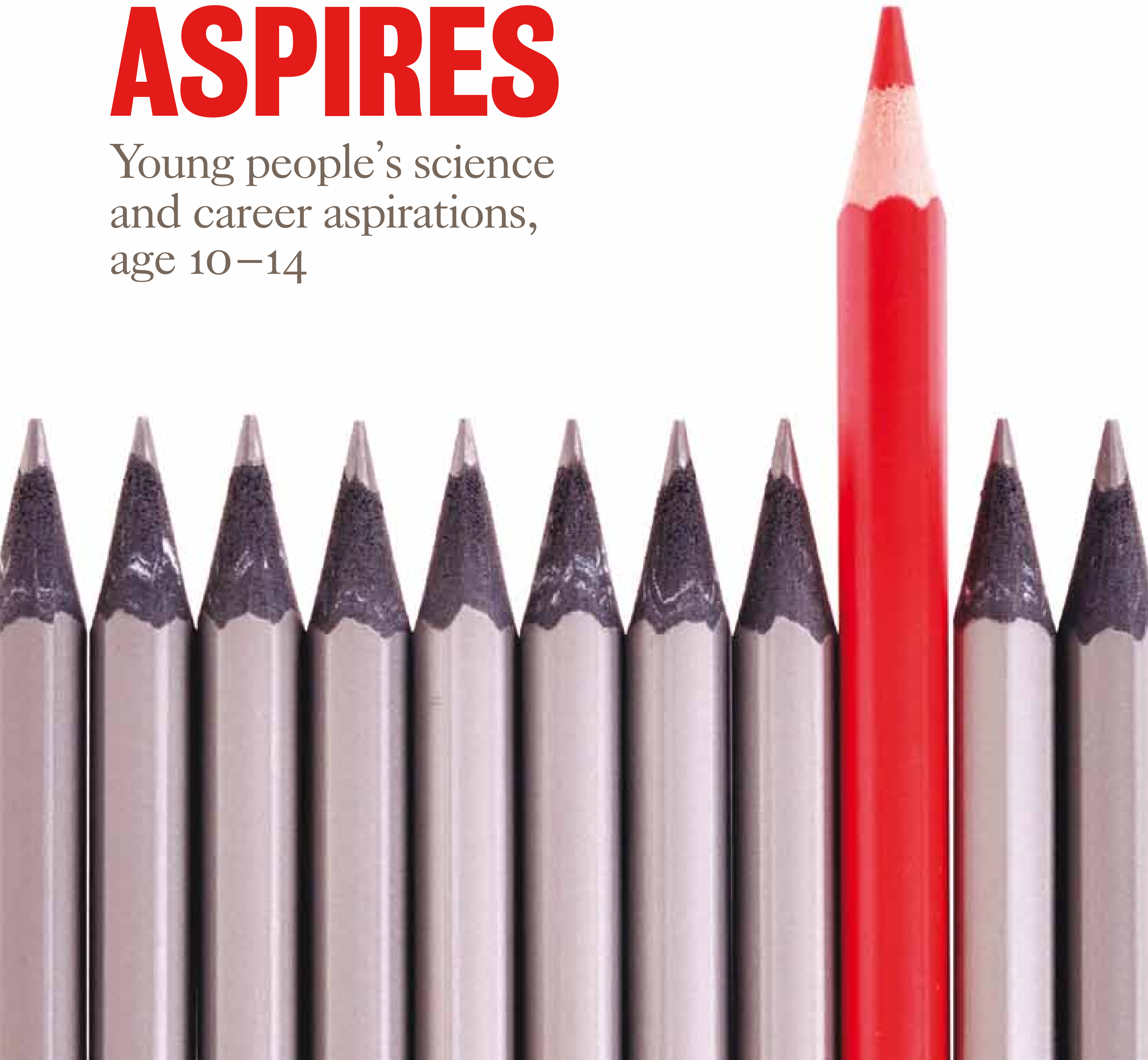
Department of Education &
Professional Studies

King's College London

ASPIRES

Young people's science and career aspirations, age 10–14



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Acknowledgements

The ASPIRES research team is: Professor Louise Archer (Director), Professor Jonathan Osborne (Co-investigator), Dr. Jennifer DeWitt (ASPIRES Research Fellow), Professor Justin Dillon (ASPIRES Intervention), Dr. Billy Wong (ASPIRES studentship) and Mrs Beatrice Willis (ASPIRES Administrative Officer).

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ASPIRES Science and career aspirations: age 10:14

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

KING'S College LONDON

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EXECUTIVE SUMMARY

Background

Many governments and organisations are concerned that not enough young people are choosing to study Science, Technology, Engineering and Mathematics (STEM) after the age of 16. There is also widespread concern that the profile of those who do go on to study STEM subjects and pursue STEM careers is too narrow, with women, working-class and some minority ethnic groups remaining under-represented, especially in the physical sciences and engineering. Particular STEM fields are predicting or already experiencing significant STEM skills gaps that may impact negatively on the economy. There is also a pressing need to improve the spread of scientific literacy across all societal groups.

The ASPIRES study sought to shed new light on our understanding of how young people's aspirations develop over this 10-14 age period, exploring in particular what influences the likelihood of a young person aspiring to a science-related career.

Methodology

The ASPIRES project is a five-year study funded by the UK's Economic and Social Research Council (ESRC) as part of its Targeted Initiative on Science and Mathematics Education (TISME)[2].

The study combines quantitative online surveys of a student cohort and repeat (longitudinal) interviews with a selected sub-sample of students and their parents. Survey and interview data were collected at three time points: the end of primary school (age 10/11, Year 6), the second year of secondary school (age 12/13, Year 8) and the third year of secondary school (age 13/14, Year 9).

In total, over 19,000 surveys were completed: 9,319 by Year 6 students, 5,634 by Year 8 students and 4,600 by Year 9 students. A sample of 83 students and 65 of their parents were also longitudinally tracked via interviews across this age range (10-14).

In addition to researching influences on students' aspirations, the project also worked with a small group of London teachers to develop approaches for integrating STEM careers information into Key Stage 3 Science lessons.

Most students like science – but do not aspire to science careers.

Key findings

Most young people have high aspirations – just not for science

The ASPIRES research found that, on the whole, most young people aged 10-14 hold relatively high aspirations for professional, managerial and technical careers. We did not find evidence of a 'poverty of aspirations' among students or parents – almost all students reported that their parents value education and want them to do well.

Yet very few young people (approximately 15 per cent) aspire to become a scientist. This aspiration remains consistently low across the 10-14 age range. It is lower than many other types of aspiration and appears disproportionately low compared to students' reported interest in science, although STEM-related careers, such as in medicine, are more popular aspirations. Business is the most popular aspiration among secondary school aged students, with almost 60 per cent of young people agreeing that they would like a career in business.

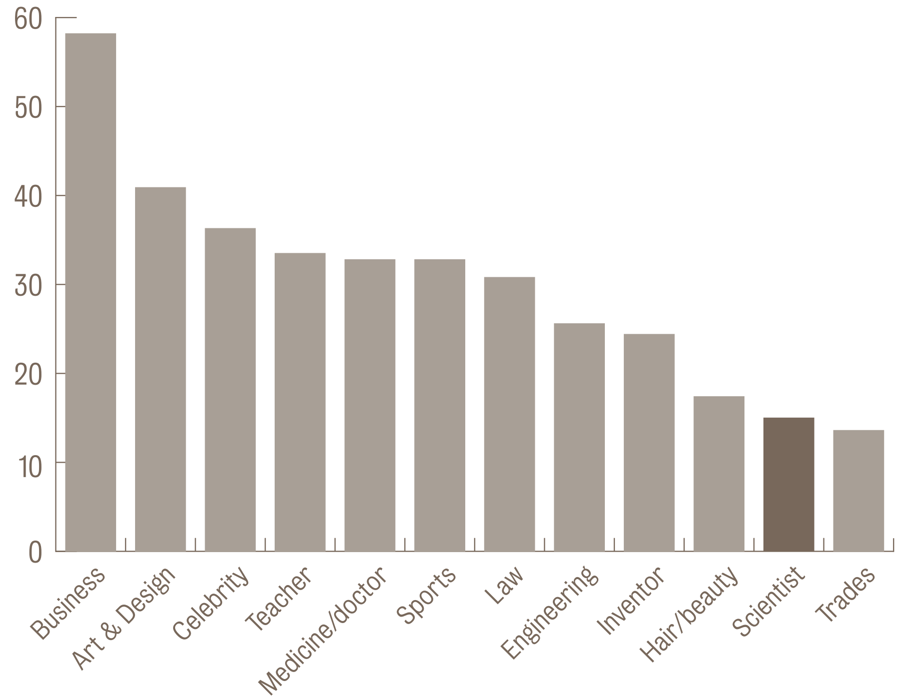
Longitudinal tracking indicates that the majority of young people's aspirations are quite consistent from the age of 10 to 14, remaining within the same broad categories (science; STEM-related; non-STEM).

Negative views of school science and scientists are NOT the problem

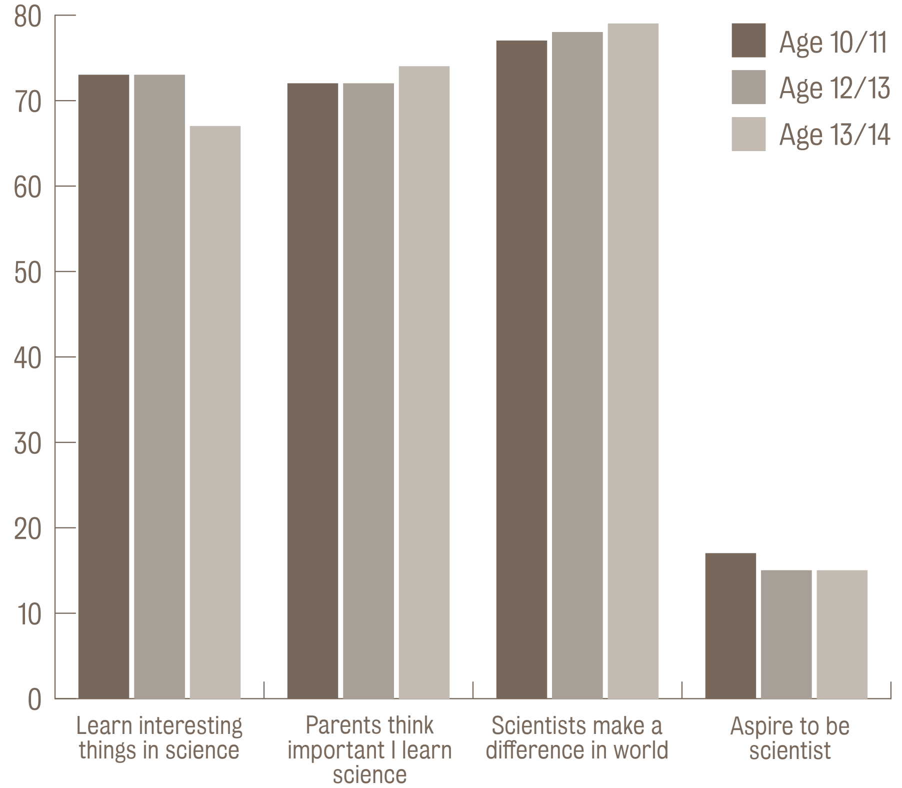
Students who express the most positive views of school science are also those most likely to aspire to science careers. However, student attitudes to school science do not fully explain science aspirations.

Our findings show that most young people report liking school science from Year 6 (at primary school) through to Year 9 (the end of Key Stage 3 in secondary school). 42 per cent of Year 9 students are interested in studying more science in the future. Students also report positive views of scientists and say that their parents think it is important for them to learn science. However, despite these widely held positive views, the majority of 10-14 year olds do not aspire to become scientists.

PERCENTAGE OF YEAR 9 STUDENTS AGREEING
WOULD LIKE THIS JOB



COMPARISON OF SURVEY RESPONSES FROM
YEAR 6, YEAR 8 AND YEAR 9 STUDENTS
(% STRONGLY/AGREEING)



'Science capital' is key to science aspirations and participation. Most young people think that science qualifications only lead to jobs such as scientist or doctor.

Family 'science capital' is key

We found that families exert a considerable influence on students' aspirations. This influence operates in many ways, but a key factor affecting the likelihood of a student aspiring to a science-related career by the age of 14 is the amount of 'science capital' a family has.

Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job).

Science capital is unevenly spread across societal groups. Those with higher levels of science capital tend to be middle-class – although this is not always the case, and not all middle-class families possess much science capital.

Students from families with medium or high science capital are more likely to aspire to science and STEM-related careers and are more likely to plan to study science post-16.

Longitudinal tracking showed that students with low science capital who do not express STEM related aspirations at age 10 are unlikely to develop STEM aspirations by the age of 14.

Most students and families are not aware of where science can lead

One implication of the widespread lack of science capital among families is that most young people and parents are not aware that science can lead to diverse post-16 routes.

We found that most young people and their parents have a narrow view of where science can lead. The widespread view – that science qualifications lead primarily to a job as either a scientist, science teacher or doctor – is contributing to many young people seeing post-16 science qualifications as 'not relevant for me'.

Those young people who are aware of the transferability of science qualifications are more likely to aspire to STEM-related careers and/or plan to study science post-16.

The brainy image of scientists and science careers puts many young people off

Over 80 per cent of young people in our surveys agreed that 'scientists are brainy'. This association influences many young people's views of science careers as 'not for me'. Students who do not consider themselves as being among the 'brainiest' in the class are unlikely to see science careers as achievable – even if they find science interesting and attain well in the subject.

The (white) male, middle-class image of science careers remains a problem

Our surveys show that a student is *most* likely to express science aspirations if he is male, Asian, has high/very high levels of cultural capital, is in the top set for science and has a family member who works in science or a STEM-related job.

A student is *least* likely to see science as 'for me' if she is female, White, has low/very low levels of cultural capital, is in the bottom set and does not have any family members who use science in their jobs.

Gender issues are evident from a young age. Girls are less likely than boys to aspire to science careers, even though a higher percentage of girls than boys rate science as their favourite subject. Girls are far more likely to aspire to arts-related and 'caring' careers. Among 12-13 year old students, 18 per cent of boys and 12 per cent of girls aspire to become scientists – in comparison, 64 per cent of girls aspire to careers in the arts.

Girls who define themselves as 'girly' (highly feminine) are particularly unlikely to aspire to a career in science. Girls who do aspire to science and STEM-related careers tend to be highly academic and are more likely to describe themselves as 'not girly'. Those 'girly' girls who do aspire to science careers at age 10/11 tend to either drop or change these aspirations over time.

The factors which hinder students from developing science aspirations are *amplified* in the case of Black students, due to the multiple inequalities they face. This means that science aspirations are particularly precarious among these students.

Efforts should focus on building science capital among students and families.

Implications and messages for policy and practice

1. Shift the policy discourse – from 'increasing interest' to 'building science capital'

ASPIRES findings show that STEM participation issues are not simply the result of students' not liking science enough. Efforts to improve participation need to move on from models based on 'increasing interest'. Given the strong influence of science capital on young people's science aspirations and post-16 study plans, we suggest that *policy-makers* and *funders* might usefully focus on 'building science capital'.

2. Earlier intervention – from primary school

Efforts to broaden students' aspirations, particularly in relation to STEM, need to begin at primary school. The current focus of most activities and interventions – at secondary school – is likely to be too little, too late.

3. Break the 'science = scientist' link

Efforts need to be directed at broadening young people's views of where science can lead and breaking the pervasive perception that 'studying science = becoming a scientist'.

For *science educators* and *careers professionals*, this could mean promoting the message that science 'keeps your options open' and is useful for a wide range of careers, at both graduate and technical levels, both in and beyond science. Emphasis should be placed on conveying the value and prevalence of science in everyday life and on science as something that is 'done by everyone' (not just scientists and science experts). Highlighting the links between science and popular aspirations (such as business) may help more young people appreciate its relevance.

Policy-makers can play a key strategic role in setting the context for intervention: currently the strong policy focus on the 'pipeline' metaphor (the flow from school science to post-16 STEM qualifications and STEM careers) is unhelpful. Instead, science might be usefully described as a 'springboard' – to emphasise its wide value within modern life and to convey how science qualifications can be valuable for propelling an individual to numerous careers and destinations. A public debate on 'what is science education for?' could be beneficial for exploring stakeholder perceptions on the value of science (e.g. as primarily for servicing the STEM 'pipeline' versus fulfilling a public scientific literacy agenda).

4. Embed STEM careers awareness in science lessons

Currently in England, there is widespread concern that careers education (information, advice and guidance) is relatively poorly resourced in schools and may not be that effective. Particular concerns have been expressed about the low quality and quantity of STEM careers education.

Careers education needs to help broaden students' awareness of the transferability of science qualifications for a wide range of careers both in and beyond science, at degree and technical levels.

Policy-makers might consider promoting embedded models of careers education, in which curriculum learning is systematically linked to a wide range of real life careers and applications. This type of approach has been found to be effective in raising student engagement and attainment[3] and has the advantage of reaching all students – but successful implementation will require appropriate policy levers and practical support for teachers.

Funders might consider supporting a UK trial of an embedded careers education model.

5. Tackle multiple inequalities

The factors which prevent a student from seeing post-16 science qualifications and careers as being 'for me' are amplified by social inequalities.

Policy-makers and *funders* might consider targeting resources at those students who are most disadvantaged.

Science teachers and *educators* should be supported to challenge unwitting biases and to provide specific support and encouragement to students from under-represented groups to enable them to see science as a potential option for their futures. Innovative attempts to develop empowering, equitable and democratic forms of science and mathematics education for disadvantaged urban youth, developed in the USA, could contain useful lessons for the UK. *Funders* might consider supporting similar trials.

STEM industries, employers, professional organisations and universities also have a part to play in working towards more equitable cultures and patterns of participation and representation within their own organisations.

6. Bust the 'brainy' image of science/science careers

Young people's views of science careers as 'only for the brainy' are reinforced and perpetuated by popular representations of scientists and by current educational practices, in which entry to science A levels is more tightly restricted than for most other subjects.

STEM educators and *careers professionals* could usefully help broaden students' views of where science leads, emphasising technical routes alongside degree routes.

STEM organisations and *policy-makers* could lobby for a greater diversity in popular and media representations of 'scientists' – particularly emphasising the problems associated with the 'brainy' image.

Policy-makers might explore the potential value of diversifying current post-16 science options (*see implications 3 and 7*) to help loosen the link between science and 'braininess' and to increase levels of post-16 science participation and scientific literacy (*see implication 7*).

7. Broaden post-16 science options

There are currently few options for students to study more science post-16 outside of the traditional Biology, Chemistry and Physics A levels. Entry to these courses tends to be more tightly restricted than to other subjects. Many young people who are interested in science are therefore unable to continue with science as a subject post-16. Expanding post-16 science provision beyond the current 'gold standard' academic model of separate science A levels may enable more students to study science post-16.

Broader options for studying science post-16 may be beneficial.

Policy-makers and *curriculum organisations* might consider the value of a new science A level that is focused on developing students' scientific literacy for a wide range of post-16 routes. This could tap high levels of student interest in science. Such a qualification would need to be open to students with a range of attainment and could focus on developing scientific literacy and skills that will be useful for a wide range of future pathways and careers. It would be essential for such qualifications to have a good status with educators and employers.

8. Build science capital with students and families

Building families' and young people's science capital will be beneficial for public scientific literacy and for encouraging more young people to continue with science post-16.

For *STEM educators*, programmes aimed at helping students and families to understand the transferable value of science qualifications could be helpful, inspiring more young people to see science as possible and personally relevant for their own futures. Supporting families to feel comfortable and knowledgeable about science and to see its relevance to their everyday lives and futures might help more students, but particularly those from under-represented groups, to develop and sustain science aspirations. *Funders* might prioritise support for interventions aimed at families, not just individual students.

1. WHY DOES PARTICIPATION IN SCIENCE MATTER?

Many governments and organisations are highly concerned that not enough young people are choosing to study Science, Technology, Engineering and Mathematics (STEM) after the age of 16. There is also widespread concern that the profile of those who do go on to study STEM subjects and pursue STEM careers is too narrow, with women, working-class and some minority ethnic groups being under-represented, especially in the physical sciences and engineering.

STEM industries are seen as crucial for national economic growth and competitiveness – yet several UK sectors are either currently experiencing, or are predicting, significant STEM skills gaps, due to a lack of appropriately qualified applicants. Ensuring that the population has a good level of scientific literacy (understanding of science) is also very important – not only because it is good for the economy, but also because it can benefit individuals and communities economically and socially, helping to promote active citizenship and enabling people to participate in, and shape, scientific and technological developments in society.

We therefore need to understand what shapes young people's aspirations and engagement with science and how students make decisions about their futures.

Ensuring that the population has a good level of scientific literacy is very important.

2. WHY STUDY ASPIRATIONS?

Previous research has shown that the period between ages 10-14 is a critical time for the development of young people's attitudes to science. By age 14, most young people's attitudes to science are fairly fixed[4]. Our study seeks to shed new light on our understanding of how young people's aspirations develop over this time, exploring in particular what influences the likelihood of a young person aspiring to a science-related career.

There are several reasons why we wanted to study young people's aspirations. First, although childhood aspirations do not accurately predict future outcomes and participation, they can give a good indication of the types of career that a young person is likely to pursue in later life[5]. Research conducted in the US also shows that students who aspire to science-related careers at age 14 are almost three and a half times more likely to end up getting a degree in the physical sciences or engineering than students without these expectations[6].

Second, for many years aspirations have been a key theme in education policy and have been the focus of numerous interventions and schemes that have sought to 'raise' or increase young people's aspirations towards particular careers, including those in STEM.

Finally, aspirations provide an interesting focus for sociological analysis, as they can allow us to explore the intersection of identities and inequalities within young people's lives.

Childhood aspirations can give a good indication of the types of career that a young person is likely to pursue in later life.

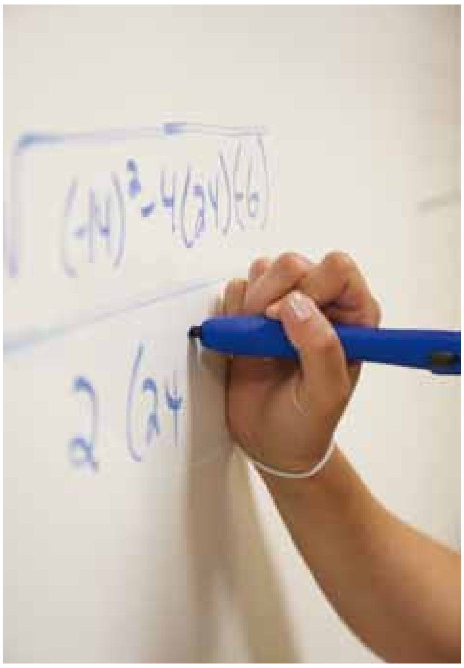
3. METHODOLOGY

The ASPIRES project is a five-year study funded by the UK's Economic and Social Research Council (ESRC) as part of its Targeted Initiative on Science and Mathematics Education (TISME)[7]. The project explores science aspirations and engagement among 10-14 year olds. It comprises a quantitative online survey of the cohort and repeat (longitudinal) interviews with a selected sub-sample of students and their parents. Survey and interview data were collected at three time points: Phase 1 was conducted at the end of primary school (age 10/11, Year 6), phase 2 in the second year of secondary school (age 12/13, Year 8) and phase 3 was administered when students were in Year 9 (age 13/14).

The three ASPIRES surveys[8] collected a range of demographic data (including measures of cultural capital[9]) and attitudinal data. Topics included: aspirations in science; attitudes towards school science; self-concept in science; images of scientists; participation in science-related activities outside of school; parental expectations; parental school involvement; parental attitudes towards science; and peer attitudes towards school and towards school science. The majority of questions used a Likert-type scale to elicit attitudinal responses. Details of the numbers of participants surveyed and interviewed at each phase are presented in Table 1.

The project explores science aspirations and engagement among 10-14 year olds.

In the first phase (Year 6, age 10/11), the survey was completed by 9,319[10] students in England, who were recruited from 279 primary schools (248 state and 31 independent schools). This sample represented all regions of the country and was roughly proportional to the overall national distribution of schools in England by attainment and proportion of students eligible for free school meals. Interviews were conducted with 92 children and 78 of their parents, who were drawn from 11 schools in England (9 state and 2 independent schools)[11]. Students came from a broad range of socioeconomic classes and ethnic backgrounds[12].



In the second phase, two years later (2011-12) 5,634[13] Year 8 students from 69 secondary schools (58 state and 11 independent schools) were surveyed. Follow-up interviews were conducted with 85 of the original 92 students[14].

In the third phase (Year 9, age 13/14), 4,600[15] students from 147 schools completed the questionnaire, of whom 1,043 had also completed the survey in Year 6. 83 students and 65 parents were re-interviewed. These students now attended 41 secondary schools in 9 areas of England and Wales.

All interviews were digitally audio-recorded and transcribed. Interviewees were invited to choose their own pseudonyms.

TABLE 1 SURVEY AND INTERVIEW PARTICIPANTS AT EACH OF THE THREE STUDY PHASES

	National Survey	Interviews (longitudinal)
Phase 1: Year 6 Age 10/11	9,319 students	92 students 78 parents
Phase 2: Year 8 Age 12/13	5,634 students	85 students
Phase 3: Year 9 Age 13/14	4,600 students	83 students 65 parents

4. WHAT DO CHILDREN AGE 10–14 ASPIRE TO?

Education policy has tended to assume that too many young people have 'low' aspirations and successive governments have made strong calls for the need to 'raise' aspirations as a way of increasing educational achievement and participation[16]. Yet, in line with wider research[17], we found that most young people express reasonably 'high' aspirations. For instance, in our Year 8 and 9 surveys, most young people aspired to professional, technical or managerial jobs. The following indicative items are from the Year 8 survey (Year 9 responses do not vary significantly):

- 91 per cent agree that it is important to them to make a lot of money
- 81 per cent would like to go to university[18]

Young people also appear to be quite altruistic and aspire to a good work-life balance:

- 96 per cent agree that it will be important to have time for family
- 90 per cent aspire to 'help others' in their working lives[19]
- 78 per cent want a career that will 'make a difference in the world'[20]

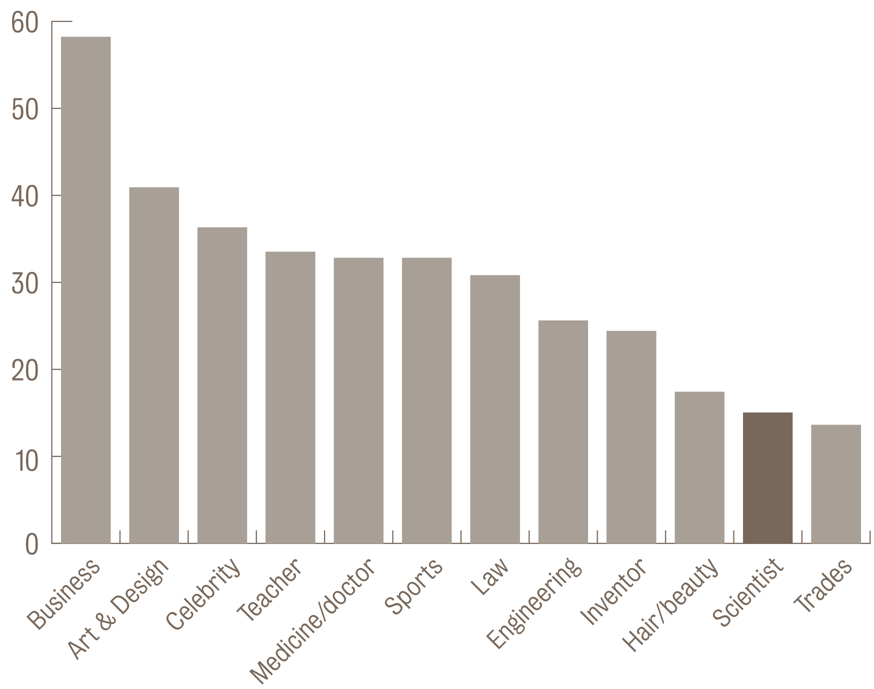
From Year 6 through to Year 9, careers in the arts, sports, medicine and teaching are all among the most popular aspirations. Business emerges as the most popular aspiration in Years 8 and 9.

Careers in science remain persistently low in popularity, with very little change in the percentage of students aspiring to be a scientist in Year 6 (17 per cent) and Years 8 and 9 (15 per cent). However, careers related to science are more popular (for example 35 per cent of Year 9 students would be happy with a job that 'uses science'). Careers in medicine are particularly popular as are, to a slightly lesser extent, careers in engineering.

Figure 1 shows the percentage of Year 9 students agreeing that they would like to do particular jobs in the future[21].

In line with a number of other studies, our research found that most young people express reasonably 'high' aspirations.

FIGURE 1 PERCENTAGE OF YEAR 9 STUDENTS AGREEING WOULD LIKE THIS JOB



The popularity of business was notable among both Year 8 and Year 9 students. There may be several reasons for this. For instance, the term 'business' may contain a wide range of potential careers, from owning an SME through to running a large multinational company and so may mean very different things to different groups of students. This point is supported by analysis of young people's answers to free response questions about their aspirations on the survey. The popularity of business may also reflect the impact of popular TV programmes such as *The Apprentice* and *Dragon's Den*, which present business and enterprise as particularly meritocratic fields that value hard work and determination above 'paper' qualifications. This may partly explain the popularity of business across gender, ethnic and social class lines. In fact, business appeared to be one of the least stereotypically profiled categories of aspiration.

5. WHO ASPIRES TO SCIENCE CAREERS?

Our statistical analyses of the survey data from over 18,000 students across the three surveys reveals a remarkably consistent picture from Year 6 to Year 8 of who is likely, or unlikely, to express science aspirations:

- A student is most likely to express science aspirations if they are male, Asian, have high/very high levels of cultural capital, are in the top set for science (in Year 9) and have a family member who works in science or a STEM-related job.
- A student is least likely to express science aspirations if they are female, White, have low/very low levels of cultural capital, are in the bottom set and do not have any family members who use science in their jobs.

This picture was also borne out by the qualitative data. Tom4 and Flower (see boxes 1 and 2) illustrate these profiles.

Survey data from over 18,000 students across the three surveys reveals a remarkably consistent picture in terms of who is likely, or unlikely, to express science aspirations.

1

Tom4 is an upper-middle-class British Pakistani boy who lives in the Home Counties. He has been identified as 'gifted and talented' since primary school. His father is a medical consultant and his mother is a businesswoman. Tom4 aspires to study science at Oxbridge, leading to a career in either medicine or business, like other successful family members ('I think that would be following my family's footsteps'). Tom4 enjoys school science and sees it as highly relevant to his own life. He achieves highly at school and is confident in his own abilities. He plans to take Triple Science at GCSE and science at degree level. He and his family are interested in science/STEM and have high family science capital. Tom4 sees post-16 science and a STEM-related career as entirely possible and achievable.

2

Flower is a working-class, White Eastern European girl who lives in a disadvantaged inner-London borough. Her mother works in a care home. Flower has aspired to be a police officer since she was in primary school, due to a desire to 'help people', although her family would rather she become a nursery teacher. Flower does not really enjoy science much at school ('I don't really like science') and is not planning to take Triple Science at GCSE nor continue with science post-16. Flower and her family have little interest in science. Flower does not see science as relevant for her future, saying 'I don't think you really need it in life, science'.

6. WHAT INFLUENCES SCIENCE ASPIRATIONS?

To date, many initiatives aimed at improving post-16 science participation have focused on trying to increase students' interest in science. However, our three surveys reveal that the relatively low proportion of students aspiring to careers in science is not due to students disliking school science. Nor is it simply attributable to low parental valuing of science or students' negative views of scientists/science careers. As can be seen in *Figure 2*, the majority of students express positive views of school science and scientists and report that their parents value science. Yet very few aspire to careers in science. We have called this disjuncture the 'being/doing divide'[22]: in other words, while the majority of students report that they like 'doing' science, most do not want to 'be' a scientist.

Our statistical analyses of the survey data show that attitudes to school science, parental attitudes to science and a student's self-concept in science (how 'good' students feel they are at science) are the factors that seem to have the strongest relationship to student science aspirations. Table 2 shows the statistical influence (effect sizes) of key variables in each survey.

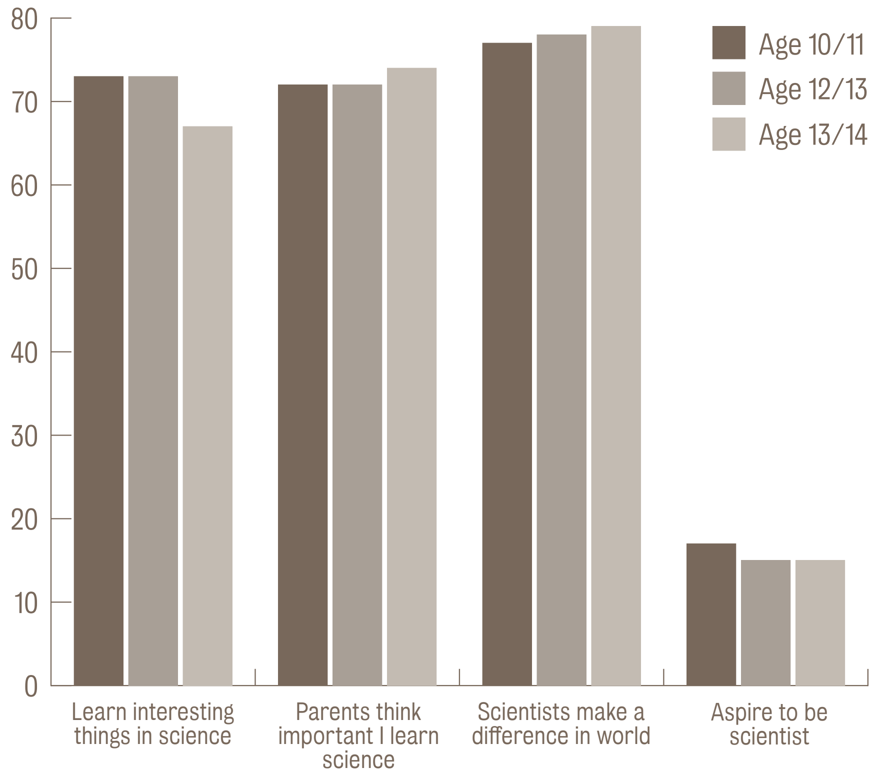
Table 2 shows the variables that are most strongly related to aspirations in science.

The effect sizes indicate the strength and direction (positive or negative) of the relationship. In educational research, effect sizes above 0.5 are typically considered large, between 0.3 and 0.5, medium and 0.1 to 0.2, small. The table reflects that attitudes toward school science and parental attitudes to science are the factors most strongly related to aspirations in science, followed by self-concept in science and participation in science-related activities outside of school (in Years 8 and 9). Gender (being female) is also related to aspirations in science, but more weakly and in a negative direction (with girls less likely to express science aspirations than boys). Although ethnicity and cultural capital do not consistently feature in the model as explanatory variables, in each of the three surveys there are clear gendered, classed and ethnic effects in terms of who is/is not likely to aspire to science (as noted in the previous section).

Drawing across the quantitative and qualitative data, we have identified a range of factors that influence science aspirations, which we discuss next.

There is a striking gap between students' positive views of science and their lack of interest in science careers.

FIGURE 2 COMPARISON OF SURVEY RESPONSES FROM YEAR 6, YEAR 8 AND YEAR 9 STUDENTS (% STRONGLY/AGREEING)



Students with high science capital are more likely to aspire to post-16 science and/or STEM-related careers.

TABLE 2 EFFECT SIZES FOR MAIN VARIABLES BY SURVEY YEAR GROUP

	Effect sizes		
Variable	**Year 6**	**Year 8**	**Year 9**
Gender (being female)	-0.13	-0.17	-0.09
Participation in science-related activities	N/A	0.23	0.21
Parental attitudes to science	0.44	0.39	0.35
Attitudes toward school science	0.53	0.51	0.48
Self-concept in science	0.20	0.21	0.24

6.1 Science capital

In the ASPIRES study we developed the concept of 'science capital' to help us understand how a student's existing resources – notably their family's understanding of, and relationship to, science – can shape the likelihood of that young person seeing post-compulsory science as a potentially possible and desirable career option.

Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job).

Our conceptualisation of science capital draws on sociological theory, and has been defined more formally as follows

> ... 'science capital' is not a separate 'type' of capital but rather a conceptual device for collating various types of economic, social and cultural capital that specifically relate to science – notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science.' (*Archer et al., 2013*).

Our study found that science capital is linked to science aspirations. That is, a child from a family with medium or high science capital is more likely to aspire to science or STEM-related careers.

We loosely classified the students whom we tracked qualitatively from age 10-14 according to whether they had high, medium or low levels of science capital:

- High science capital: parents/nuclear family members with degree level STEM qualifications and/or STEM careers and one or more family members express an interest in science (16 families)
- Medium science capital: parents/nuclear family members with non-degree level, post-compulsory STEM qualifications (e.g. A levels) and/or extended family members with STEM qualifications/jobs and one or more family members express an interest in science (20 families)
- Low science capital: no parents/nuclear family members with post-compulsory STEM qualifications and/or STEM jobs. Family members may or may not express an interest in science (47 families)

Figure 3 (Year 6) and *4* (Year 9) show how levels of science capital relate to the likelihood of a child expressing science aspirations. The figures, from Year 6 and Year 9 students, appear to show that the influence of science capital increases with age. In particular, it seems that having medium or high science capital is associated with a greater likelihood of a student expressing science or STEM-related aspirations, whereas low science capital is more likely to be associated with a student expressing non-STEM aspirations[23].

By Year 9, 60 per cent of students with **high science capital** have science or STEM-related aspirations. Students with high science capital who aspire to non-STEM careers still plan to continue with science post-16, taking Triple Science GCSE and naming science among their favourite subjects. High status STEM-related (medical/vet) aspirations are particularly popular with this group. There is a relatively high level of consistency over time, with around 60 per cent of students with high science capital aspiring to the same broad category of aspirations (STEM, STEM-related or non-STEM) from Year 6 to Year 9.

By Year 9, 60 per cent of students with **medium science capital** have science or STEM related aspirations. Just over half of students with medium science capital expressed consistent aspirations for jobs in a given category (science, STEM-related or non-STEM) from Year 6 – Year 9. Compared to students from high and low science capital groups, medium science capital students are more likely to change their aspirations from one category to another over time. This change is mainly due to the growing popularity of STEM-related aspirations from Year 6 to Year 9 among this group of students.

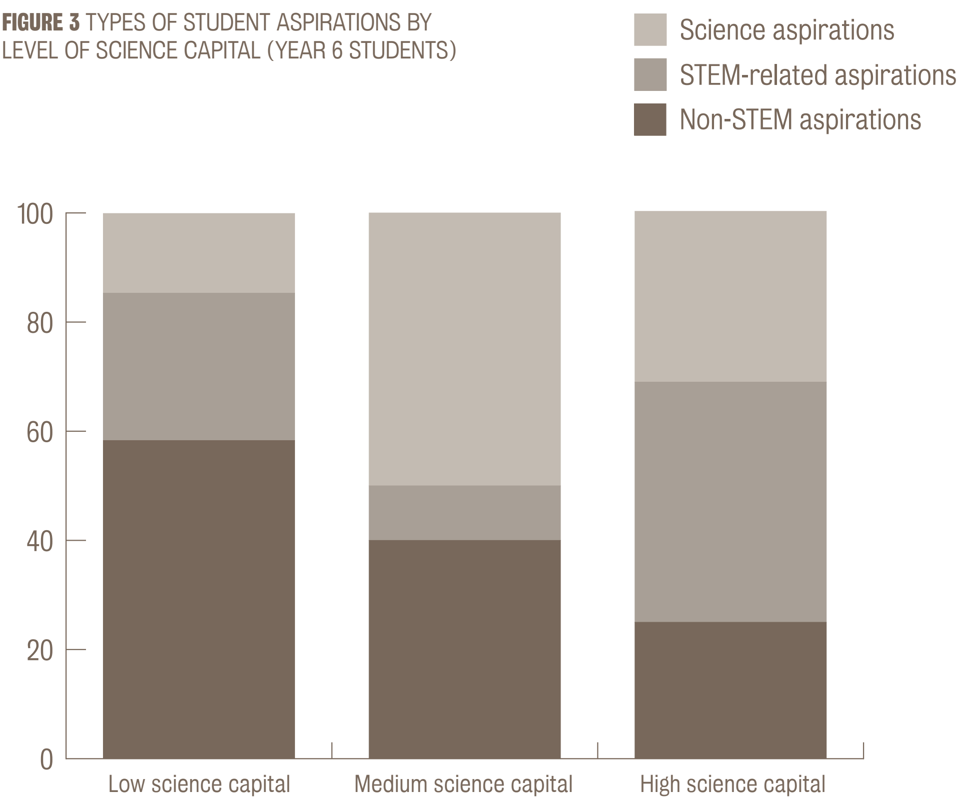
By Year 9, 32 per cent of students with **low science capital** express science or STEM-related aspirations, but only one of these students actually holds a science aspiration (the others are all STEM-related). No students with low science capital aspired to any type of science job consistently from Year 6 to Year 9. Students with low science capital are more likely than those with medium or high science capital to aspire to non-STEM careers and to express these non-STEM aspirations consistently from Year 6 to Year 9. Indeed, overall this group expresses the highest degree of consistency in aspirations, with 72 per cent of students expressing aspirations within a consistent category (namely STEM-related and non-STEM) from Year 6 to Year 9. Of the seven students identified in Year 6 as having 'raw' science aspirations (science aspirations but low capital), by Year 9, four are aspiring to non-STEM careers and three to STEM-related careers.

In the surveys and interviews, most students said that their parents have generally positive attitudes towards science. Yet there are great variations in the extent to which families know about science, are interested in it and have science or STEM-related qualifications. Put differently, positive attitudes to science seem to stretch across different levels of familial science capital, suggesting that positive parental attitudes to science are not, themselves, sufficient to lead to aspirations in science, even though they are an influence.

Unsurprisingly, given the way we have categorised levels of science capital, there is a strong relationship between social class and levels of science capital. For instance, those students with high science capital were predominantly from middle-class,

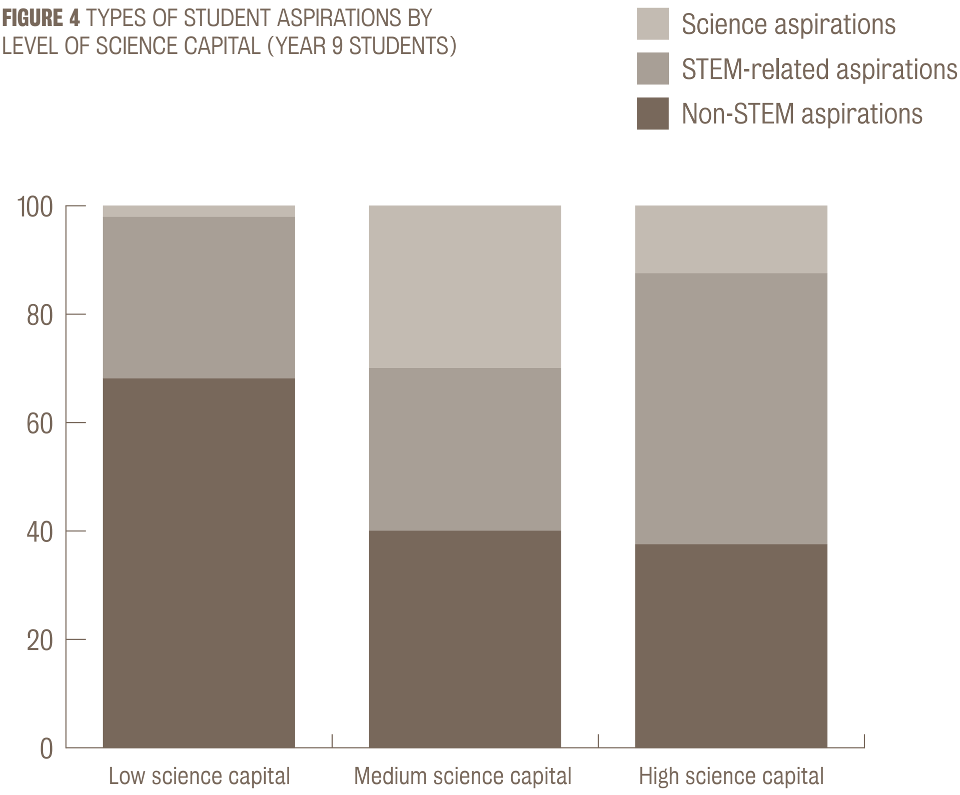
The effect of science capital on student aspirations increases with age.

FIGURE 3 TYPES OF STUDENT ASPIRATIONS BY LEVEL OF SCIENCE CAPITAL (YEAR 6 STUDENTS)



A child with low science capital who does not aspire to science at age 10 is highly unlikely to develop science aspirations by the age of 14.

FIGURE 4 TYPES OF STUDENT ASPIRATIONS BY LEVEL OF SCIENCE CAPITAL (YEAR 9 STUDENTS)



professional families. But not all middle-class families possessed medium or high science capital.

Our analysis of the qualitative data also explored family attitudes to science and the extent to which there is an encouragement and fostering (or not) of science in everyday family life, as constituted for instance through pastimes, activities, leisure consumption, TV, books, topics of conversation and social networks. In other words, we explored the extent to which science is 'woven' into the everyday fabric of family life.

We identified different 'types' of relationship that families have with science[24]. These ranged from 'science families', who had high levels of science capital and for whom science was part of everyday family life, through to families for whom science is largely absent from or peripheral to their lives (see *Boxes 3* and *4*).

For most students in the study, science was not a common feature of their everyday lives and leisure time. A few parents claimed that they actively dislike science, often based on their own negative experiences of science at school[25]. But the majority of families seemed to have fairly benign or ambivalent views about science, although many students felt that because science was not a common topic of conversation, they had "no idea... not a clue" (as one of the students, MacTavish, put it) what their families think about science. These children tended to articulate the sentiment that while they enjoy 'doing' science, they cannot envisage pursuing a career in science. In other words, they were 'interested, *but...*'[26]

Seeing science as transferable

Families with higher levels of science capital were more likely to be aware of science qualifications as valuable and transferable in the labour market, i.e. leading to many different types of job or attracting a wage premium. Students and families with lower levels of science capital (the majority) were more likely to see science qualifications as only leading to careers as a scientist, science teacher or doctor.

Findings from the UPMAP study suggest that views on the transferability (usefulness) of science qualifications are important predictors of whether students go on to study STEM subjects post-16[27]. UPMAP's survey of 7,000 Year 10 and Year 12 students found that perceived material gain (*'I think Physics will help me in the job I want to do in the future'*) is one of most important factors predicting whether students will choose to study the subject post-16.

43 per cent of 13–14 year olds say they would like to study more science in the future.

3

'Science Families': example, Davina and Dawkins

Davina attends an independent girls' school. From primary school she has aspired to follow a science career. She sees herself as different in this respect to many of her peers, saying 'I'm definitely more interested in science, certainly than people that I hang around with anyway. Definitely a lot more'. She has a number of family members who have studied science to degree level and pursued science careers. Davina's father, Dawkins, studied science at Oxbridge. Although her mother does not have particular science qualifications, she too feels 'sciencey'. The family enjoy watching science TV programmes and it is a regular topic of conversation. As Dawkins explains, 'we talk science in the household'.

4

'Science is peripheral' families: example quotes

Science was relatively peripheral to the daily lives of many families in the study, as illustrated by the following:

'I suppose in everyday life you don't get that much really to do with it [science]' (Jane2, mother of Dave)

'I don't think that any of us are really that...[sciencey]' (Robyn, mother of Charlie)

'I've never really asked them about science' (Heather)

'They never talk about science' (Jack)

The ASPIRES surveys also seem to underline this point. For example, when asked to identify the most important reasons for choosing subjects to study in the future, over four fifths (86 per cent) of the Year 8 survey students identified the usefulness of a subject for their future careers as being the first or second most important factor. Over 70 per cent of Year 8 and Year 9 students also recognised that science can be useful for getting a good job, but far fewer felt that such jobs were personally relevant or attainable. This may in part explain the gaps between the high proportion (over 70 per cent) of students who report finding school science interesting, the 43 per cent of students on the same survey who agreed that they would like to study more science in the future and the very small number who aspire to become a scientist (approximately 15 per cent)[28].

6.2 Experiences of school science

One factor that remained remarkably consistent across all three surveys was students' attitudes to school science. From Year 6 to Year 9, the majority of students reported positive attitudes towards school science. Statistical analyses (multilevel modelling) indicated that, in each survey, students' attitudes to school science was the variable most closely related to their aspirations in science (as noted in *Table 2*). Of the students participating in the Year 9 survey, a subset (1,036) had also completed it in Year 6 (a group we call the 'tracked sample'). Analysis of the data from this group confirmed that there is a strong relationship between students' attitudes to school science and the likelihood of a student holding science aspirations. *Table 3* shows the variables that are most strongly related to Year 9 aspirations in science for this tracked sample.

Table 3 shows how students' aspirations in science at Year 9 are related to their aspirations in science at Year 6. However, a range of other variables are more closely related to their Year 9 aspirations in science, such as how well a student feels they do in school science ('self-concept in science'), parental attitudes to science and, especially, their attitudes to school science. This consistently close relationship between attitudes to school science and aspirations in science suggests that a student's experience of school science may influence the extent to which they consider a science career to be 'for me'.

It is important to note, however, that the 'attitudes to school science' variable is a *composite* variable – that is, it combines

TABLE 3 FACTORS RELATED TO YEAR 9 ASPIRATIONS IN SCIENCE (YEAR 6 – YEAR 9 TRACKED SAMPLE)

Variable	Effect size
Year 6 aspirations in science	0.16
Family member whose job uses science	0.17
Attitudes towards school science (Y9 data)	0.5
Parental attitudes to science (Y9)	0.35
Self-concept in science (Y9)	0.19
Participation in science-related activities (Y9)	0.15
Family member whose job uses science	0.17

students' responses from a number of survey statements, probing their views on different aspects of school science. Although the overall mean score for the 'attitudes to school science' composite variable does not drop significantly from Year 6 to Year 9, we did find that students' responses to particular questions about aspects of school science did change over time, as shown in *Table 4*.

Table 4 shows that students are generally positive about school science from Year 6 to year 9 – they seem to value it, report high teacher expectations and believe that they can do well in it if they work hard. However, students seem to enjoy their lessons less over time, particularly as they move into Year 9, with progressively fewer students saying they learn interesting things, find science lessons exciting and look forward to science lessons. This decrease in enjoyment of science lessons is also borne out within the qualitative data, which suggests that an increasing emphasis on test preparation and writing, in contrast with practical work, may be reducing students' enjoyment of science lessons – a trend likely to be exacerbated during GCSE preparation at Key Stage 4 (KS4).

Students aged 10-14 are generally positive about school science.

The relationship between students' attitudes to school science and the likelihood of expressing science aspirations suggests that school science lessons could be an important space for interventions aimed at nurturing and promoting student science aspirations. This idea chimes with research conducted in the USA, which suggests that school science experiences can powerfully influence the extent to which science is perceived to be 'for me'[29]. At the same time, our data suggest that improving students' experiences of school science lessons alone is unlikely to improve student science aspirations, given that student attitudes to school science are already quite positive. Moreover, a gap remains between students' generally high, positive ratings of school science and the much smaller proportions of students expressing science aspirations (see Figure 2). Finally, our statistical analyses cannot indicate causality. That is, while there is a relationship between students' attitudes to school science and their likelihood of expressing science aspirations, this relationship may be mediated by a range of factors, but particularly science capital. Indeed, our analyses show that students with high levels of science capital tend to report more positive attitudes to school science.

Student self-concept and the 'brainy' image of science

As noted in *Table 2*, how well students feel they do in school science ('student self-concept in science') is consistently related to science aspirations in all three surveys.

TABLE 4 ATTITUDES TO SCHOOL SCIENCE ACROSS SURVEYS (YEAR 6 – YEAR 9)

	Percentage agreeing/strongly agreeing		
Survey questions/items	Year 6	Year 8	Year 9
If I study hard, I will do well in science	80.6	82.3	81.4
My teacher expects me to do well in science	68.4	69.9	71.4
Studying science is useful for getting a good job in the future	79.9	84.8	83.8
We learn interesting things in science lessons	73.8	73.2	65.7
Science lessons are exciting	58.1	52.1	42.9
I look forward to my science lessons	51.7	47.8	42.7

Science careers are widely seen as only for the 'brainy' few.

That is, the more students feel that they do well in science, the more likely they are to express science aspirations. We also found that those students who say that they are in top sets for science are more likely to express science aspirations than those in middle or bottom sets. For instance, 43 per cent of students who claimed to be in top sets for science expressed a desire to work in science compared to 14 per cent of those in the bottom sets (and 21 per cent of those in the middle sets).

Overall, Year 9 students are generally positive about their performance in science, with nearly two thirds agreeing that they do well and get good marks in science and only 23 per cent finding it difficult (a small rise from Year 8, when 19 per cent of students reported finding science difficult). Yet this positive self-concept is not translating into aspirations in science, at least not for those outside of top sets. It seems that even though students think they can do well in school science, this does not translate into aspirations to pursue science careers or to become a scientist.

Survey data suggests that this may be because students see 'scientist' as an unobtainable career. For instance, 79 per cent of Year 9 students (81 per cent in Year 6 and 80 per cent in Year 8) agree that scientists are 'brainy'. It would seem that popular perceptions of science careers as being only for the exceptional 'brainy' few may be putting off the majority of young people from seeing science careers as 'for me', irrespective of how well they feel they do in school science.

> "She [daughter] said 'oh, you have to be really clever [to study science]... She says 'I'm not clever enough to be good at science'" (Sandra, mother).

Wider academic literature has discussed how 'cleverness' is a profoundly racialised, classed and gendered concept, which tends to be associated with white, middle-class masculinity[30]. As a result, teachers (and students themselves) are less likely to recognise working-class, minority ethnic and female students as 'naturally' clever. Studies show how attainment among these groups is more likely to be attributed to 'hard work' than natural aptitude, while under-achievement among White, middle-class boys tends to be explained as due to 'laziness' rather than a lack of ability. Due to the association of 'cleverness' with white middle-class masculinity, and the close association between science and 'braininess', we suggest that female, working-class and some minority ethnic students may be less likely to imagine themselves following science careers – even though they like science and aspire highly. Moreover, those students who do aspire to science careers may have to exhibit considerable resilience to sustain such aspirations over time. These issues were particularly notable among the Black students in our qualitative sample – as will be discussed further in section 6.6.

6.3 Views of STEM careers

It is commonly assumed that the popular stereotype of the 'geeky scientist' may be dissuading students from wanting to continue with science post-16. Our data, however, suggest a more nuanced picture. Only 21 per cent of students completing the Year 9 survey agreed that scientists are 'geeks' and even fewer (14 per cent) believed that scientists are 'odd'. Only 18 per cent of Year 9 students agreed those who work in science have few other interests and 25 per cent think that scientists spend most of their time working by themselves. Year 9 students were less likely to subscribe to these stereotypes than Year 6 students, suggesting that young people's views of scientists improve – or become less stereotypical – over time.

"What would I do with science?" (Buddy, age 14).

The survey responses indicate that the majority of young people hold broadly positive views of scientists. For instance, 79 per cent of Year 9 students agreed that scientists 'can make a difference in the world', a proportion virtually unchanged from Year 6. Similar views were expressed in interviews, with students often giving examples of how science benefits society, such as through advanced technologies and medical breakthroughs (e.g. curing cancer). However, we suggest that – in combination with the widely held view that scientists are 'brainy' (see section 6.2) – these positive views contribute to a commonly held perception of scientists as 'exceptional' individuals, which may prevent many young people from seeing careers in science as being 'for me'.

This popular view – of science careers as only for the very clever few – is exacerbated by the narrow understanding students have of where science can lead. We found that few students are aware of the broad range of careers (both in and beyond science) that science qualifications can lead to. As Buddy (age 14) repeated at several points during his interview, he does not intend to study science post-16 because "what would I do with science?" Alan (age 14) also concurred, reflecting "there's no point doing [studying] science and then getting a job that doesn't use science". Like many of their peers, neither Buddy nor Alan were aware of the diversity of potential careers that might be opened up by science qualifications, despite a vague appreciation that science itself might be useful in 'lots of jobs'.

6.4 Gender: Girls, boys and science aspirations

There is widespread concern that women remain under-represented in the physical sciences at post-compulsory levels and in science careers. This is often referred to as the 'leaky pipeline', whereby women and girls participate in progressively smaller numbers as they move along the science qualifications and career 'ladder'.

In the ASPIRES study we sought to understand whether some of the factors that contribute to the 'leaky pipeline' might be discernible among girls age 10-14. We also wanted to know whether there are any comparable issues for boys.

We found evidence of gendered subject preferences in both our survey and interview data. For example, the Year 9 survey showed that more boys than girls plan to continue studying physics post-16 (37 per cent boys, 20 per cent girls). There were no gender differences in terms of studying biology. Proportions planning to study chemistry were also quite comparable – 36 per cent of boys and 31 per cent of girls. As we discuss next, we also found that the likelihood of a student expressing science aspirations is patterned by gender, social class and ethnicity.

6.4.1 Girls' science aspirations

As noted in earlier sections, we found that girls tend to be less likely than boys to express science aspirations. Yet this was not due to girls liking science less than boys. For example, the Year 8 survey showed that a higher percentage of girls than boys rate science as their favourite subject, yet girls were still less likely than boys to aspire to science careers. In the Year 8 and 9 surveys, 18 per cent of boys and 12 per cent of girls

Science aspirations are less common among 'girly' girls.

aspired to become scientists. To put these figures in context, this compares with 64 per cent of Year 8 girls and 50 per cent of Year 9 girls who aspired to careers in the arts.

Through the interviews we explored how and why different girls saw science careers as 'thinkable', or not. We found that girls who define themselves as 'girly' (highly feminine) are particularly unlikely to aspire to a career in science[31]. Those girls who do aspire to science and STEM-related careers tend to be highly academic and are more likely to describe themselves as 'not girly'[32] – although there were a couple of exceptions (e.g. see Davina, below). Medicine was a particularly popular aspiration, as a high status, professional career which is also concerned with 'helping people'.

It was also notable that those 'girly' girls who did aspire to science careers at age 10/11 tended to either drop or change these aspirations (particularly to medicine) over time. One contributory factor is the widely held view that science jobs are predominantly done by men. Even parents who were supportive of their daughter's science aspirations recognised that girls will probably have to work 'twice as hard' to succeed in a male-dominated field such as science, especially in the physical sciences.

Some parents recognised the need to build resilience in their daughters. For example, Hailey's mother described how her daughter's early experiences – as the only girl playing in an otherwise all-male cricket team – could provide a good grounding for the future, particularly if she chooses to pursue a science-related career.

By Year 9, girls who aspire to science careers are very much a minority among their peers. One such girl, Davina, described her recognition of being 'odd' in this respect, not only due to her science aspirations, but also because she is more 'girly' than the other girls she knows who like science:

> "I think I'm quite strange, like I mean I'm interested in science and I do want to do science ... and I want to take it all the way ... but then I think I'm still like quite social, I do like going out to like parties and stuff... For example a lot of the people that do science, like a lot of them don't have boyfriends. And I'm like well I'm kind of weird, cos I have one but then ... and I'm like friends with people who have in the past or currently do have [boyfriends]... but then they [my friends] have completely

> different interests, and they like completely different subjects. So I think I am sort of not the norm really" (Davina, Year 9 interview).

Girls who aspire to careers in science may require considerable resilience to maintain their aspirations over time, especially knowing that they are relatively unique or unusual in this respect. Our longitudinal qualitative data showed that girls who maintain science or STEM-related aspirations over time tend to be from middle-class backgrounds and largely possess high or medium levels of science capital. As is discussed in the next section, two Black, working-class girls did 'buck the trend' in Year 9, aspiring to careers as forensic scientists. Their stories, and the facilitating and hindering factors that they encounter, are explored in more detail in section 6.5.

6.4.2 Boys' science aspirations

Very few studies have used gender as a focus for looking at boys' aspirations and engagement with science. In this respect, our analysis of the relationship between masculinity and science aspirations is a relatively novel contribution to the academic literature[33].

Science, but especially the physical sciences and engineering, are widely seen as male-dominated fields, a perception that is largely borne out by degree participation rates and workplace profiles. However, not all boys participate equally in post-16 science. Through the interviews, we explored what makes science more 'thinkable' for some boys and not others.

Boys who aspire to science and/or STEM careers were loosely categorised as either being highly academic boys who define themselves as 'not cool/not sporty', or as being 'cool', fashionable/sporty boys. Whereas by Year 9, 'feminine' girls with science-related aspirations were very much in the minority, it was notable that boys who aspired to science and/or STEM careers were far more evenly divided between those who are cool/sporty and those who are not.

We found that those boys who aspire to careers in science tend to possess medium to high levels of science capital. Boys with lower levels of science capital were more likely to aspire to STEM-related careers, rather than careers in science.

'Laddish' boys and those with low science capital tend not to aspire to science careers.

Our analysis suggested that an interplay of masculinity, cultural/familial discourses and science capital meant that some boys, but particularly those from White and South Asian middle-class backgrounds, experience an easier 'fit' between their sense of self and an imagined future in science.

More 'laddish' boys (those who behave in a more cheeky, irreverent way, who enjoy 'having a laugh', football and popular masculine pastimes more than academic work) tend to possess the lowest levels of science capital and are particularly unlikely to consider 'brainy' science careers as being for them, even though many like science and enjoy it at school.

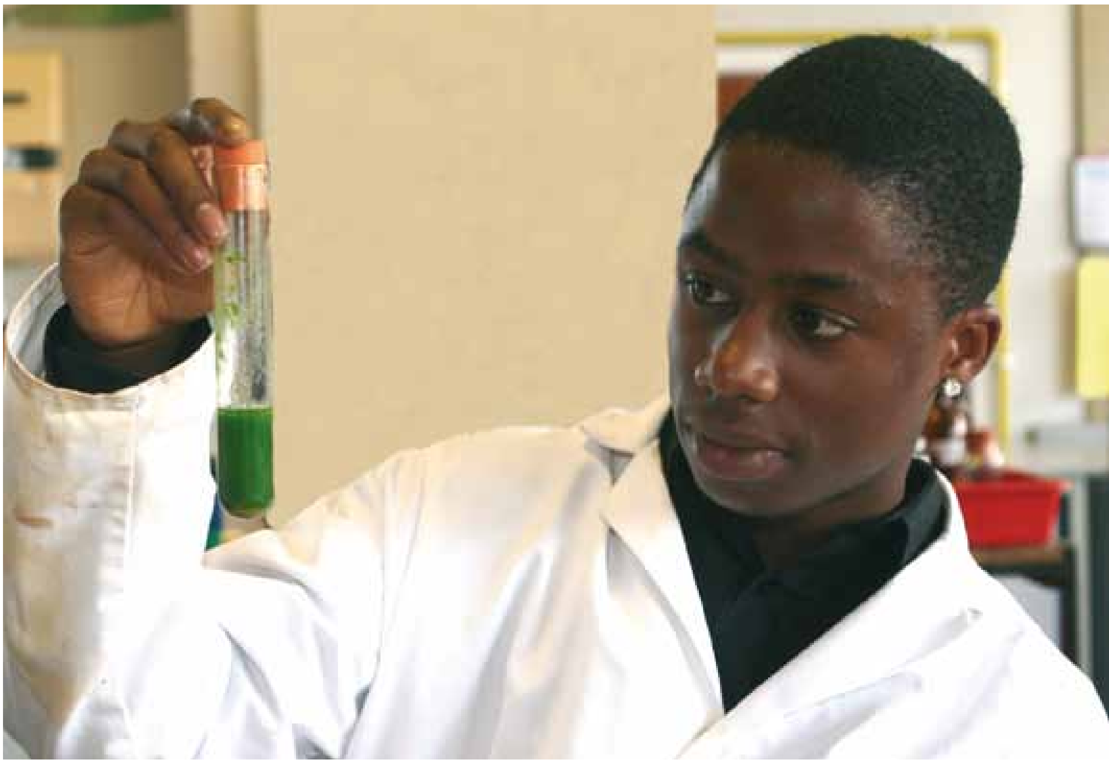
Boys who align themselves with 'clever', highly academic masculinity are more likely to see science as something that is desirable and congruent with their sense of self. Academic boys with high levels of science capital are more likely to hold science aspirations and/or plan to study science post-16. Among these boys, even those who do not aspire to science or STEM-related careers report valuing science as an essential component of informed citizenship.

6.5 Ethnicity and science aspirations

The Year 6 survey showed that Asian students expressed the strongest science aspirations of any ethnic group, followed by Black and then White students[34]. Similar patterns emerged in the data from the Year 8 and Year 9 surveys, with Asian students reporting significantly higher aspirations than other ethnic groups[35]. Taken together, the three surveys suggest an overall picture in which Asian students consistently express stronger aspirations in science than White students. Black students also tend to have stronger aspirations than White students, though not as strong as Asian students (and the effect sizes of these differences are very small, $\omega=.1$). The qualitative data similarly showed that Asian students are most likely out of all ethnic groups to express aspirations for careers in, but particularly from, science (with medicine being particularly popular). Indeed, in the interview sample, only one South Asian student had *never* held a science-related aspiration.

However, national post-16 participation figures suggest that the relatively high science aspirations expressed by Black students in our surveys may not translate into later participation rates. Given that there is relatively little academic literature on Black

Black students are disadvantaged by multiple inequalities – not a poverty of aspirations.



students' science aspirations, we conducted an in-depth analysis of our qualitative data to explore the issues.

It has been suggested that Black students tend to be under-represented in higher education, and particularly in fields such as science, due to their lower attainment, interest and/or aspirations. Yet none of these explanations were borne out by our data. For instance, only one Black student was in lower school sets (the others were in top sets or middle sets), with several reporting achieving high grades in their courses and being eligible to take the prestigious Triple Science option for GCSE[36].

There was also no evidence of low family aspirations. All families aspired highly for their children, irrespective of social class. All parents and children described strong parental support, motivation and high expectations for children to continue into higher education and achieve a professional career. Several parents also provided practical support, such as paying for private tutoring. There was no evidence of Black students lacking interest in science, with all students reporting liking science to some degree.

So if lack of interest is not the issue, what causes differential patterns in science aspirations? Based on our analyses, we suggest that the factors hindering Black students are largely common factors that affect all groups of students, but these are amplified in the case of Black students, due to the multiple inequalities they face.

For example, the widespread view of science qualifications as predominantly leading to a narrow range of careers (as a scientist or doctor) and stereotypes of scientists as being mostly White, male and middle-class[37], were particularly notable among Black students and their parents. These views made post-compulsory science and science careers seem particularly unattractive. As Tom2 put it, "I'd find it boring. Wearing a white coat, walking around with glasses". Gemma also concurred, saying "I just don't like the thought of me being a scientist".

Most of the Black students we interviewed viewed science as leading only to careers in science – jobs which they personally had little interest in. This meant that although they liked science, and often did well in it at school, they did not feel that science is personally relevant or necessary for their future working lives. Indeed, it was notable that many students (but particularly Black students) were much more likely to see English and mathematics as useful for 'most' jobs, but regarded science as of more limited utility. As Pamela explained, "English and Maths are used more widely but Science ...

like unless you want to be a scientist, isn't as relevant to you".

Some Black parents recognised that they personally lacked knowledge and awareness of where science can lead, and felt that this might be a disadvantage for themselves and their children. As one mother, Bunmi, put it "if you do Science, what can you be later in the day?" It is perhaps little surprise that many Black students choose to aspire to 'known' jobs rather than those in the unknown domain of science.

> "The problem is the lack of knowledge, the lack of awareness, [of] where you know certain subjects like this can take them" (Tasha, Alan's mother).

Irrespective of their personal levels of attainment, interest and aspirations in science, Black students in the interview sample tended to consider science to be a 'hard', 'difficult' subject, with science careers being only for the '*brainy*'. They expressed similar views to the wider sample, but were more likely than students from other ethnic backgrounds to agree that it is only "the clever people" who are really into science. For instance, despite attaining reasonably well and being in the top and middle sets at schools, Cristiano still felt that he was not exceptional enough to contemplate a career as a scientist.

Drawing on wider academic literature, we suggest that Black students may find it more difficult than many other groups of students to be recognised as 'clever science students'. This is due to racism (when Black people are associated with a 'lack of intelligence'), which is compounded by differential expectations according to gender and social class – in which working-class Black boys and girls have historically been stereotyped as low attaining, 'problem students'[38].

The Black families in our sample also tended to possess low levels of *science capital*. As Saadiah explained bluntly, "I don't know about the science". They also tended to be among the more economically disadvantaged families in the study, suggesting a compounding of forms of disadvantage.

Bucking the Trend: two working-class Black girls aspiring to science careers

Despite the issues outlined above, our longitudinal qualitative data revealed that in Year 9, two Black working-class girls, Selena and Vanessa, did aspire to careers as forensic scientists. What made science more 'thinkable' for them?[39]

Both girls enjoy school science and are academically orientated. Their parents strongly value and support their education. Both girls gravitate towards academically likeminded friendship groups and attend

The image of science careers as white, male and middle-class is still a problem.

a single-sex girls' school[40]. Neither is particularly 'girly', and Selena describes herself as a 'tomboy'. Both enjoy popular crime dramas, such as *CSI Miami* (which prominently features a Black woman forensic scientist).

Selena attains highly at school and is recognised as a 'clever' student. Vanessa, while not doing quite as well at school, stands out for the high level of science capital in her family and the strong motivation she receives from her father (who has an overseas pharmacy degree and works as a school science technician).

However, both girls experience some risk factors that could potentially mediate their aspirations in the future: neither girl has been consistent in her aspirations over time; both hold multiple, competing aspirations alongside their interest in forensic science; and both their mothers have reservations about forensic science as a viable career route (preferring medicine as a safer option) – a view borne out by media coverage of the over-subscription and diminishing career opportunities associated with forensic science.

'My dad is really good at science and maths, so I would really like to be good at that too' (Vanessa, age 14).

7. THE ASPIRES INTERVENTION

Developing approaches for integrating STEM careers awareness into KS3 science classes

Teachers worked with ASPIRES to develop ways of embedding STEM careers information within science lessons.

As part of our study, we worked directly with a group of teachers from selected London schools to develop ways to translate key messages from the study into practice. In particular, we were interested in working with teachers to develop ways of embedding STEM careers information within KS3 science lessons – notably the message that science qualifications can lead to a wide range of careers both in and beyond STEM at graduate and technical levels.

7.1 Participating schools

Schools were approached via a number of routes, often using existing links between project staff and science teachers. Six schools from across Greater London signed up to the first phase of the intervention: Two mixed comprehensives, two single-sex comprehensives (one girls, one boys), one mixed independent and one single-sex boys independent school.

All of the teachers involved recognised the key issues that the ASPIRES project was addressing and could see how careers advice in school was often too little, too late. They recognised how the intervention could fit into the 'How Science Works' part of science in the National Curriculum.

All of the teachers in the project were very committed to it although they all experienced considerable time pressures and constraints on their participation. Towards the end of the project, an attempt was made to recruit a new cohort of teachers to test whether approaches and activities developed during the first phase of the intervention could be adapted and used in science classrooms by other teachers. Two King's PGCE chemistry students, teaching at a mixed Catholic comprehensive school in an inner London borough, volunteered to take part in this second phase of the intervention. They attended a briefing meeting at King's College London and then trialled an activity developed by one of the original group of teachers.

7.2 Data collection

Various data were collected throughout the intervention. In the first phase this included:

- Pre-intervention student questionnaires (providing an opportunity for teachers to compare their students with the findings from the broader ASPIRES surveys);
- Lesson observations;
- Pre- and post- student questionnaires around a Year 9 STEM weeks intervention at the single-sex girls comprehensive school;
- Focus group interviews with Year 10 girls at the girls' comprehensive c. six months after their participation in the STEM weeks intervention;
- Focus group interviews conducted by UKRC (in 2011) with teachers and students from two boys' schools;
- Interviews with three participating teachers (one individual, one paired) towards the end of the intervention (February/March 2013).

Despite the initial enthusiasm and commitment of the teachers most were unable to find time for their students to complete post-intervention surveys or participate in post-discussion groups (with the exceptions noted above).

For the second phase of the intervention, data were collected via lesson observations and facilitated group discussions with students before and after the activities trialled by the PGCE student teachers.

7.3 Case studies

The decision was taken early in the intervention that teachers would be encouraged to devise their own strategies for adapting existing resources to meet the needs of their particular students. The teachers invested considerable time in the development work and provided updates on their progress at successive professional development sessions. Some schools focused on introducing careers-related material into each curriculum topic, whereas others focused on adapting resources to be used in after-school contexts. The teachers were encouraged to write case studies for their own benefit and for the benefit of other teachers. Assistance was provided in devising and writing the case studies by the ASPIRES researcher.

Eleven case studies were produced, written by teachers from three schools. The Association for Science Education kindly agreed to host the case studies on their website so they can be widely accessed[41].

7.4 Reflections and findings

The participating teachers felt that it is very important to integrate teaching about careers in and from science into their science teaching. While relatively few of the participating teachers had significant science work experience beyond teaching, they all

'It changed the way we think': interventions successfully broadened students' views of where science can lead.

saw the value in integrating information about careers in and from science into their lessons or out-of-school activities.

There is no shortage of careers resources that can be relatively easily adapted by science teachers. The existing material is reasonably up-to-date, gender equitable and engaging. However, few of the teachers were aware of the materials before they took part in the intervention.

Even initially keen teachers found it hard to find the time to take part in the project. Data analysis and feedback from schools suggested that the most effective approach for integrating careers information into teaching is likely to be 'drip-feeding' – integrating STEM careers links as a regular feature within nearly every lesson. Participating teachers found that, once they had started, it was not necessarily difficult to do this. However, they recognised that getting started is, in itself, challenging, particularly without external support.

Students who took part in the intervention, but particularly those involved in the second phase, said that the online resources they had encountered had usefully broadened their knowledge of the range of jobs that exist in and from science. As one student commented:

> "I also think that it's quite good to go on those websites.... like they showed like some jobs that I didn't really know that could involve actual science. Like there's like all these big like huge jobs going 'You can earn money'. Cos like no one really wants their job to be like a shopkeeper like stacking stuff on the shelf all their life – everyone wants to like be like all big and have like good jobs." (Year 7 student)

In terms of impact, many of the students interviewed expressed an interest in occupations that they had never thought of before the intervention:

> "Before I done that I never thought like of any other jobs, all I wanted was like to do sports. Always my dad ... and my family was telling me like to think of a job, but I couldn't really like find out any interesting things. But when I done the thing [at school] it really made me like find loads of new jobs that like interested me." (Year 7 student)

It was in the inner London girls' comprehensive school that we were able to collect the most substantial data set to help inform our analysis of the effectiveness of the developed strategies and approaches[42]. The focus of this analysis was a six-week programme of STEM activities that were put together by the school STEM coordinator for Year 9 students. Students completed pre- and post- questionnaires and we conducted classroom observations, three student discussion groups (c. six months after the intervention) and an interview with the school STEM coordinator (c. two years after the intervention).

Analysis of the data suggested that there was no single story across the qualitative and quantitative data sets. But findings indicate:

- There was no significant impact of the intervention on student aspirations or attitudes to school science, as measured by the questionnaire – although there were some positive changes to students' responses to particular questionnaire questions/statements.
- The intervention had a positive effect on broadening students' views of the range of careers that science can lead to. For instance, students identified twice as many non-STEM jobs on the post-intervention questionnaire. These changes were also evident in the discussion groups six months after the intervention. As the girls put it: "it made us aware that there's so many paths to science"; "it changed the way we think"; "it shows it's not only, you know, doctors and stuff".
- The intervention may have a potential value for fostering resilience among students with pre-existing STEM aspirations.
- The intervention may have a potential value for engaging those students who were previously 'bored' by science.
- It is very important that interventions promote careers both in and from science, ensuring that these cover jobs at both graduate and technical levels.

8. CONCLUSIONS & IMPLICATIONS FOR POLICY & PRACTICE

It is commonly agreed that more needs to be done to improve (widen and increase) STEM participation. The science workforce remains insufficiently diverse – and particular fields are predicting, or currently experiencing, STEM skills gaps that will impact negatively on the economy. There is also a pressing need to improve the spread of scientific literacy across all social groups in society.

The ASPIRES project investigated the factors influencing young people's science and career aspirations and sought to understand what enables, or prevents, young people from seeing post-16 science and STEM careers as being potentially 'for me' or 'not for me'.

Our conclusions and recommendations focus on seven key points:

8.1 'Liking science is not enough': a new message for STEM policy, practice and enrichment

- The ASPIRES research shows that, in general, most young people have relatively high aspirations.
- Most young people report liking school science from primary (Year 6) through to the end of Key Stage 3 (up to Year 9) at secondary school. They also report positive views of scientists and parental support for them to learn science at school.
- However, the majority of 10-14 year olds do not aspire to science careers. In other words, students' comparatively low aspirations to become scientists are not the result of finding science boring.
- *Implication:* The solution to participation problems does not lie in simply trying to 'raise' young people's aspirations. Nor does it lie in trying to increase students' interest in science – which has been the basis of many interventions to date.

Action needs to begin at primary school – age 14 is too late.

8.2 Earlier intervention is needed – from primary school

- ASPIRES research shows that from the ages of 10 to 14, science aspirations remain consistently low compared to other types of aspiration and relative to students' reported interest in science.
- Longitudinal tracking over the 10-14 age period shows that the majority of students' aspirations remain within the same broad categories (science, STEM-related, or non-STEM) over this time frame.
- Students with low science capital who do not express STEM-related aspirations at age 10 are unlikely to develop STEM aspirations as they get older.
- *Implication:* Efforts to broaden students' aspirations, particularly in relation to STEM, need to begin in primary school. Currently most activities and interventions are targeted at secondary school students.

8.3 The pervasive 'science = scientist' link is detrimental: disrupting the pipeline metaphor may be helpful

- The ASPIRES research found that most young people and their families have a relatively narrow view of where science can lead. The popular view – that science qualifications lead primarily to a job as either a scientist, science teacher or doctor – is contributing to young people seeing post-16 science qualifications as 'not relevant for me'.
- Current policy discourse, and much STEM enrichment activity, prioritises the science pipeline metaphor, encouraging young people to study science as a route to attaining a science career. This may undermine the value of science for scientific literacy and may hinder young people from realizing the relevance of science for a wide range of jobs.
- *Implication:* Breaking the pervasive 'studying science = becoming a scientist' link may be beneficial for improving post-16 science participation.
- *How?*

  – The pipeline metaphor should be de-emphasised in favour of promoting the message that 'science keeps your options open', opening doors to a wide range of careers at both graduate and technical levels, both in and beyond science. Greater emphasis should be placed on the value and prevalence of science in everyday life and on science as something that is 'done by everyone' (not just scientists and science experts).

  – Highlighting how science qualifications may be relevant for a wide range of popular aspirations (such as business) may help more young people understand its relevance to their own lives.

  – Instead of using the science pipeline metaphor, science might be more usefully described as a 'springboard' – to emphasise its wide value within modern life and to convey how science qualifications can be valuable for propelling an individual to numerous careers and destinations.

Trial evidence from the US shows that linking classroom learning to careers information can significantly raise student attainment and engagement.

– A public debate on 'what is science education for?' could be beneficial for exploring stakeholder perceptions of the value of science (e.g. as primarily for servicing the STEM 'pipeline' versus fulfilling a public scientific literacy agenda) and for testing out the feasibility of new metaphors.

8.4 Better STEM careers education for all: embedding STEM careers awareness in mainstream science lessons

- ASPIRES found that most young people and their parents have little awareness of the diversity of routes that science can lead to. Those young people/families who are aware of the transferability of science qualifications are more likely to plan to study post-16 science and/or aspire to STEM-related careers.
- Currently in England, there is widespread concern that careers education (information, advice and guidance) is relatively poorly resourced in schools and/ or may not be that effective. Particular concerns have been expressed about the low quality and quantity of STEM careers education.
- *Implication:* More needs to be done in schools to help broaden students' awareness of the transferability of science qualifications and their relevance for a wide range of careers, both in and beyond science, at degree and technical levels.
- *How?*
  – Evidence suggests that teachers can be influential and trusted sources of careers information, advice and guidance.
  – Embedded models of careers education (in which curriculum learning is systematically linked to a wide range of real life careers and applications) have been found to be effective in raising student engagement and attainment (e.g. see a randomised control trial of the CareerStart programme in the US)[43].
  – Embedded models of careers education have the advantage of reaching all students – but successful implementation will require appropriate policy levers and practical support for teachers[44].

8.5 Tackling multiple inequalities

- The ASPIRES project found that science capital is unevenly spread across different social and economic groups in society. Some groups of students

The sector needs to convey the message that science leads to a wide range of jobs in and beyond science, both at degree and technical levels.

are disproportionately likely to be disadvantaged and are consequently less likely to see science careers as being 'for me'.

- *Implication:* it may be beneficial to target intervention at particular groups, particularly if resources are limited.
- *How?*
  – Support teachers and educators to challenge unwitting biases[45] and to provide specific support and encouragement to students from under-represented groups, to help them to see science as potentially relevant for their futures.
  – In the US there are currently some innovative attempts to develop empowering, equitable and democratic forms of science and mathematics education for disadvantaged urban youth. These approaches combine young people's home knowledge and experiences with science and maths knowledge and skills to transform young people's lives, both in and out of school[46].
  – Currently, many gender-based STEM participation interventions focus on providing role models and/or 'positive images' of science (e.g. ensuring that images of STEM professionals are appropriately diverse, representing a range of gender and ethnic backgrounds). But other research suggests that a more fruitful and long-lasting approach would be to support teachers and students to understand and challenge ('deconstruct') gender stereotypes and messages[47].
  – It is not enough to seek to change only young people's attitudes and perceptions. STEM industries, employers, professional organisations and universities all have a part to play in working towards more equitable cultures and patterns of participation and representation within their own organisations.

8.6 Busting the 'brainy' image of science/ science careers

- ASPIRES found that there is a widespread association of science/scientists with 'braininess' and that this association influences many young people's views of science careers as 'not for me'.
- Science and other high status 'masculine' subjects are particularly likely to be associated with 'braininess' and exclusivity.
- *Implication:* more needs to be done to challenge the view of science as 'only for the brainy'
- *How?*
  – Young people's views of science, as 'only for the clever', are reinforced and perpetuated by current educational practices. For example, in England it is common for access to A level study to be more tightly restricted in the sciences than other subjects (e.g. students tend to have to achieve an A or A* grade at GCSE in order to be eligible to study A level Physics, whereas a lower grade B or C is more common as an entry requirement for other subjects, such as English[48]).
  – Broadening students' views of where science leads, emphasising technical routes alongside degree routes, should be helpful (see 8.3)
  – Greater diversity in popular and media representations of 'who does science' could help further loosen the association between science and braininess.
  – A greater diversity of post-16 science options (with non-elite entry requirements) may be key to loosening the link between science and 'braininess' (see 8.7).

8.7 Beyond the 'gold standard': broadened post-16 science options

- ASPIRES found that 42 per cent of Year 9 students[49] are interested in studying more science in the future. Yet figures indicate that these relatively high levels of interest do not translate into later participation rates.

Interventions should be aimed at families, not just students.

- There are currently few options for students to study more science post-16 outside of the traditional Biology, Chemistry and Physics A levels. Entry to A level science subjects tends to be more tightly restricted than in other subjects (see 8.6).
- *Implication:* Expanding post-16 science provision beyond the current 'gold standard' academic model of separate science A levels may enable more students to study science post-16.
- *How?*
  – There is a potential case to be made for the introduction of a broader range of post-16 science pathways and types of qualification. These would need to be open to students with a range of attainment and could focus on developing scientific literacy and skills that will be useful for a wide range of future pathways and careers. It would be essential for such qualifications to have a good status with educators and employers.

8.8 Building science capital with students and families

- The ASPIRES study highlighted the importance of 'science capital' and its relationship to young people's science aspirations and views of post-16 science. Students from families possessing medium or high science capital are more likely to aspire to science and STEM related careers and are more likely to plan to study science post-16.
- ASPIRES highlighted how families are generally influential on student aspirations.
- *Implication:* building families' and young people's science capital will be beneficial for public scientific literacy and for encouraging more young people to continue with science post-16.
- *How?*
  – Programmes aimed at helping students and families to understand the transferable value of science qualifications could be helpful for inspiring more young people to see science as possible and relevant for their own futures.
  – Interventions should be aimed at families, not just individual students. Supporting families to feel comfortable and knowledgeable about science and to see its relevance to their everyday lives and futures might help more students, but particularly those from under-represented groups, to develop and sustain science aspirations.

FURTHER INFORMATION, PUBLICATIONS & IMPACT ACTIVITIES

For further information about the ASPIRES project and an up-to-date list of publications and further contact details, please visit our website: **www.kcl.ac.uk/aspires**

ASPIRES academic publications (2010-13)

– Archer, L. DeWitt, J. & Dillon, J. (in press). "It didn't really change my opinion": exploring what works, what doesn't, and why in a school STEM careers intervention. *Research in Science and Technological Education*

– Archer, L. DeWitt, J. & Osborne, J. (under review). Is Science for Us? Black students' and parents' views of science and science careers.

– Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2013). Not Girly, not sexy, not glamorous: Primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Society*, 21 (1), 171-194.

– Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong. B. (2012). "Balancing acts": Elementary school girls' negotiations of femininity, achievement, and science. *Science Education*, 96 (6), 967-989.

– Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2012). Science aspirations and family habitus: How families shape children's engagement and identification with science. *American Educational Research Journal*, 49(5), 881-908.

– Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2010). 'Doing' science vs 'being' a scientist. *Science Education*, 94(4), 617-639.

– Archer, L., DeWitt, J. & Willis, B. (2013) Adolescent boys' science aspirations: masculinity, 'race', capital and power. *Journal of Research in Science Teaching*.

– Archer, L. DeWitt, J., & Wong, B. (2013) Spheres of Influence: What shapes young people's aspirations at age 12/13 and what are the implications for education policy?, *Journal of Education Policy*, iFirst.

– DeWitt, J., Archer, L., & Osborne, J. (accepted with minor revisions). Science-related aspirations across the primary-secondary divide: Evidence from two surveys in England.

– DeWitt, J., Archer, L., & Osborne, J. (2013). Nerdy, brainy and normal: Children's and parents' constructions of those who are highly engaged with science. *Research in Science Education*, 43(4), 1455-1476.

– DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B., & Wong, B. (2013). Young children's aspirations in science: The unequivocal, the uncertain and the unthinkable. *International Journal of Science Education*, 35(6), 1037-1063.

– DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B. & Wong, B. (2011). High aspirations but low progression: The science aspirations-career paradox amongst minority ethnic students. *International Journal of Science and Mathematics Education*, 9 (2), 243-271.

– Wong, B. (2012). Identifying with science: A case study of two 13-year-old 'high achieving working class' British Asian girls. *International Journal of Science Education*, 34(1), 43-65.

Conferences and presentations

Talks and presentations that the ASPIRES team have made to date include:

2009

- Evolving Science Communication conference, Bristol

2010

- Association for Science Education conference, Nottingham
- National Association for Research in Science Teaching (NARST) Annual Conference, Philadelphia, Pennsylvania
- British Educational Research Association (BERA) Annual conference, University of Warwick
- Keynote at the Education and Employers Taskforce conference

2011

- British Educational Research Association Annual conference, London
- European Science Education Research Association conference, Lyon, France
- Keynote at Science for Careers Conference, National STEM Centre, York
- National Association for Research in Science Teaching (NARST) Annual Conference, Orlando, Florida
- Association for Science Education Conference, University of Reading

2012

- National Association for Research in Science Teaching (NARST) Annual Conference, Indianapolis, Indiana
- American Educational Research Association (AERA) Annual Conference, Vancouver

- 'Beyond STEM: Policies and practices for a better society' conference, Department for Education, London

2013

- Targeted Initiative on Science and Mathematics Education conference, Glasgow
- Association for Science Education Summer Celebration conference, University of Hertfordshire
- Association for Science Education conference, University of Reading
- Keynote at Science Careers conference, National STEM Centre, York
- Opening Keynote, European Science Education Research Association (ESERA) Cyprus
- 'Children's science aspirations and social inequalities' conference, London
- Keynote symposium, British Educational Research Association Annual Conference, Sussex
- ECSITE (European Network of Science Centres and Museums) conference, Gothenburg, Sweden
- Science Communication Conference: London
- National Association for Research in Science Teaching (NARST) Annual Conference; Rio Grande, Puerto Rico.
- Invited talks at: Brunel University; University of Exeter; Institute of Physics

ASPIRES accessible and practitioner articles and publications

– Archer, L., Osborne, J. & DeWitt, J. (2012). Ten Science Facts & Fictions: The Case for Early Education about STEM Careers. London, KCL/The Science Council

– Article on ASPIRES for SecEd: file:///C:/Documents%20and%20Settings/k0927327/My%20Documents/ASPIRES/Dissemination/Impact/Copies%20of%20articles%20and%20press%20releases/SecEd%20article%2021%20June%202012.html

– 'Why do so few children aspire to science careers?' published in the Australian Career Practitioner. Summer 2012

– Article drawing on the ASPIRES research published in Britain in 2012 (published by the ESRC). http://www.esrc.ac.uk/publications/britain-in/index.aspx

Media coverage

– 11 January 2012, article in *The Scotsman* entitled 'Children feel science careers 'are limited', based on ASPIRES 'Ten Science Facts and Fictions' report. http://www.scotsman.com/news/education/children_feel_science_careers_are_limited_1_2046977

– 12 January 2012: 'Ten Science Facts and Fictions' report gets mentioned on BBC Radio Kent

– 19 January 2012: ASPIRES report is mentioned by Kate Bellingham in interview on Radio 4. http://news.bbc.co.uk/today/hi/today/newsid_9681000/9681563.stm

– 27 January 2012: Article in *New Scientist* highlighting ASPIRES research: http://www.newscientist.com/article/dn21397-lets-give-science-a-bad-name-in-schools.html

– 20 January 2012: Article on Yahoo News entitled 'Careers in Science Don't Appeal to Teens', Say Researchers. http://news.yahoo.com/careers-science-don-t-appeal-teens-researchers-012015843.html

– 30 January, 2012: Article on ASPIRES in *TES* http://www.tes.co.uk/article.aspx?storycode=6169457

– 16 August 2012: Futurity website: http://www.futurity.org/society-culture/teens-skip-science-and-go-for-the-money/

– December 2012, article by Greg Hurst in *The Times*, entitled 'A science job? You've got to be Einstein, say children', based on ASPIRES findings

– January 2013: Professor Archer interviewed for BBC Radio Ulster by Wendy Austin about children and their aspirations to work in science

– March 2013: Professor Archer talks about ASPIRES findings for International Women's Day podcast: https://www.kcl.ac.uk/newsevents/the-gender-agenda.aspx

– 19 March 2013: Professor Archer is quoted in an article in the *Daily Telegraph* ('Why don't more girls study physics?') http://www.telegraph.co.uk/education/secondaryeducation/9929672/Why-dont-more-girls-study-physics.html

– June 2013, *Evening Standard* letters, 'The art v science debate: your views': http://www.standard.co.uk/comment/comment/the-art-v-science-debate-your-views-8619504.html?origin=internalSearch

– http://euroscientist.com/2013/06/do-science-girls-have-an-image-problem/

– 2013 ESRC Website 'Science Still no child's play' http://www.esrc.ac.uk/news-and-events/features-casestudies/

features/20129/Science_still_no_childs_play.aspx
– 4 July 2013: Article in *The Independent* about Enterprising Science, which draws on ASPIRES research: http://www.independent.co.uk/news/education/education-news/the-art-of-teaching-them-to-love-science-8686313.html

Policy engagement

– Invitation to Number 10 for briefing meeting with Susan Acland-Hood, Special Policy Adviser (6 September 2012)
– Invitation to present and inform British Gas Brazil/UK STEM Education Exchange programme (11 October 2012)
– ASPIRES referenced in Parliamentary Office for Science and Technology (POST) POST Note, March 2013 http://www.parliament.uk/briefing-papers/POST-PN-430
– ASPIRES invited blog for British Science Association http://www.britishscienceassociation.org/blog/what-influences-participation-science-and-maths16 May 2013
– ASPIRES citation in Women's Business Council report (4 June 2013): http://womensbusinesscouncil.dcms.gov.uk/
– Professor Archer invited to be member of Institute of Physics expert groups on Girls and Physics and Ethnicity and Physics
– Collaboration with EDT, a STEM enrichment organisation who are using ASPIRES findings to inform their STEM family challenge intervention programmes

ENDNOTES

[1]Members past and present include: Jenny Baker, Derek Bell, Kate Bellingham, Rebecca Edwards, Becky Francis, Harvey Goldstein, Nicola Hannam, Matthew Harrison, Gill Kirkup, Alec Mannion, Katherine Matthieson, Nicole Morgan, John Myers, Helen Myrtle, Clare Nix, Vanessa Pittard, Michael Reiss, Annette Smith, Libby Steele, Juliet Strang, Matthew White, Annette Williams.

[2]tisme-scienceandmaths.org

[3] E.g. see a randomised control trial of the *CareerStart* programme in the US.

[4]Lindahl, B. (2007). *A Longitudinal study of students' attitudes towards science and choice of career*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. New Orleans, Louisiana. Omerod, M.B., & Duckworth, D. (1975). *Pupils' attitudes to science*. Slough: NFER. Murphy, C., & Beggs, J. (2005). *Primary science in the UK: A Scoping study. Final report to the Wellcome Trust*. London: Wellcome Trust. The Royal Society. (2006). *A degree of concern? UK first degrees in science, technology and mathematics*. London: The Royal Society.

[5]Croll, P. (2008). Occupational choice, socio-economic status and educational attainment: a study of the occupational choices and destinations of young people in the British Household Panel Survey. *Research Papers in Education, 23*(3), 243-268.

[6]Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science, 312*, 1143-1144.

[7]tisme-scienceandmaths.org

[8]Full details of the survey and its methods, analyses and findings are discussed in separate publications, e.g. DeWitt et al, 2011, 2013, which also further provide further detail on the reliability and validity of the survey instrument, as well as the specific items.

[9]Cultural capital was determined by responses to items such as parental university attendance (and leaving school before age 16), approximate number of books in the home and frequency of museum visitation. These items were used to provide an overall indication of level of cultural capital. Students in the Year 6 survey fell into the following categories: very low (2 per cent), low, (23.3 per cent), medium (34.1 per cent), high (20.3 per cent) and very high (20.3 per cent).

[10]Of the students who completed the survey there were: 50.6 per cent boys, 49.3 per cent girls; 846 (9.1 per cent) in private schools, 8473 (90.9 per cent) in state schools; 74.9 per cent White, 8.9 per cent Asian (Indian, Pakistani, Bangladeshi heritage), 7.5 per cent Black (Black African, Black Caribbean), 1.4 per cent Far Eastern, 7.8 per cent mixed or other.

[11]Potential schools were purposively sampled from the list of 279 schools who responded to the Phase 1 survey as part of the wider study to represent a range of geographic and social/economic contexts, including multiethnic urban, suburban and rural schools.

[12]Students were asked to self-categorise their ethnic background on the surveys via a double-level question, which directed students to particular detailed choices in the second part, depending on how they answered the first, more general level part of the question. Overall, Year 9 students fell into the following (self-reported) ethnic categories: White, 71.2 per cent (n=3276), Asian 13.5 per cent (620), Black 6.2 per cent (286), Chinese/East Asian 1.5 per cent (69), Other, 7.6 per cent (349) . This distribution among ethnic categories was similar for the Year 6 and Year 8 samples.

[13]Of the 5634 students who participated in Survey 2, 2251 (40.0 per cent) were boys and 3358 (59.6 per cent) were girls. (25 students did not provide their gender). 5226 (93 per cent) attended state schools and 408 (7 per cent) attended independent schools. 711 of the 5634 students who completed Survey 2 also completed Survey 1.

[14]37 boys and 48 girls.

[15]Of the 4600 students completing Survey 3, 44.4 per cent were male and 55.4 per cent were female. 96.5 per cent attended state schools and 3.5 per cent attended private schools.

[16]This has remained consistent from the New Labour administration (e.g. Department for Education and Skills (2005) Higher Standards, Better Schools for All. London, Stationary Office) to the Coalition, e.g. the Secretary of State for Education, Michael Gove's, calls in the 2010 Schools White Paper for the creation of an 'aspiration nation' (Department for Education, 2010, The Importance of Teaching - The Schools White Paper 2010, London).

[17]E.g. Croll, P. (2008). Occupational choice, socio-economic status and educational attainment: A study of the occupational choices and destinations of young people

in the British Household Panel Survey. *Research Papers in Education*, *23*, 243–268.

[18]Comparable figure is 80 per cent on Year 9 survey

[19]Comparable figure is 87 per cent on Year 9 survey

[20]Comparable figure is 77 per cent on Year 9 survey

[21]Students were asked this question about a variety of jobs and thus could express interest in more than one job.

[22]Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education, 94*(4), 617-639.

[23]STEM-related aspirations include aspirations that are directly related to science, technology, engineering and mathematics, and which would often expect or usually involve one or more post-16 qualifications in a STEM subject, such as medicine (e.g. doctor, vet, physiotherapist). Careers related only to mathematics and not other STEM fields (e.g. accountant) were not included in this analysis.

[24]Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science Aspirations, Capital, and Family Habitus: How Families Shape Children's Engagement and Identification With Science. *American Educational Research Journal, 49*(5), 881-908

[25]See Reiss, M., J. (2001). How to ensure that pupils don't lose interest in science *Education Today, 51*(2), 34-40.

[26]As we have written elsewhere (Archer et al., 2010) this lack of interest in becoming a scientist emerged strongly in our separate qualitative pilot sample of London primary school children, who expressed an interest in science but who stated that they did not want to become scientists in the future (and is borne out by the main survey data).

[27] http://www.ioe.ac.uk/study/departments/cpat/4814.html

[28]40 per cent in Year 6, 43 per cent in Year 8 and 42 per cent in Year 9 said they were interested in studying more science in the future

[29]Carlone, H. B., Haun-Frank, J., & Webb, A. (2011). Assessing equity beyond knowledge- and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching, 48*(5), 459-485.

[30]Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2013). Not Girly, not sexy, not glamorous: Primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Society*, 21 (1), 171-194.

[31]Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013b). 'Not girly, not sexy, not glamorous': primary school girls' and parents' constructions of science aspirations 1. *Pedagogy, Culture & Society*, 1-24.

[32]Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). "Balancing acts'': Elementary school girls' negotiations of femininity, achievement, and science. *Science Education, 96*(6), 967-989.

[33]Archer, L., Dewitt, J. and Willis, B. (in press, 2013) Adolescent boys' science aspirations: Masculinity, capital and power. Published online in *Journal of Research in Science Teaching*.

[34]As reflected by their mean scores on a composite variable comprised of items related to aspirations in science (i.e. 'I would like to study more science in the future', I would like to have a job that uses science', I would like to work in science', 'I would like to become a scientist' and 'I think I could become a good scientist one day'). On this variable, White students had a mean of 13.3, whereas the mean for Asian students was 15.8 and Black students 14.4. The difference among these groups was significant, $F(5, 9313) = 41.98$, $p < .001$ and post-hoc comparisons (Bonferroni) reflected that the score of Black students was significantly lower than that of Asian students but significantly higher than that of White students.

[35]In particular, the Year 8 the means for aspirations in science were, Black 14.75, White, 14.03 and Asian 15.91, and in Year 9, the means were Black 15.51, White, 13.81, Asian 15.96. Although ANOVA analyses reflected significant differences among the groups in both years ($p < .001$ for each), post-hoc comparisons highlighted that in Year 8 only Asians were significantly higher than other groups: Black and White students expressed science aspirations at a similar level to one another. In Year 9, Black and Asian and students of 'other' ethnicities all expressed significantly higher science aspirations than White students. However, multilevel modelling analyses (which take into account a variety of background variables) suggest that although these

differences exist among the groups, ethnicity does not have as close of a relationship with aspirations as other factors (such as gender, attitudes to school science or parental attitudes to science).

[36]Schools tend to select only the highest attaining students as eligible to study for this, the highest status, option for studying science at GCSE.

[37]See Scantlebury, K. Tai, T. & Rahm, J. (2007). "That don't look like me." Stereotypic images of science: Where do they come from and what can we do with them? *Cultural Studies of Science Education, 1 (3),* 545-558.

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[40]The IOP report 'Different for Girls' shows that attending a single-sex girls school is associated with a far greater probability for a girl to take A level Physics.

[41]See 'Resources' section: http://www.ase.org.uk/resources/aspires-project-teaching-about-science-careers/

[42]See Archer, L., DeWitt, J. & Dillon, J. (Accepted). "It didn't really change my opinion": Exploring what works, what doesn't, and why in a school STEM careers intervention. *Research in Science and Technology Education*.

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[48]DfE (2012). Subject progression from GCSE to AS Level and continuation to A Level (pp. 30). London: Department for Education.

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