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HIGH ASPIRATIONS BUT LOW PROGRESSION: THE SCIENCE ASPIRATIONS–CAREERS PARADOX AMONGST MINORITY ETHNIC STUDENTS

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ABSTRACT. Students' interest in studying science and their aspirations to pursue science-related careers is a topic of global concern. In this paper, a set of data gathered for the initial phase of the 5-year study of Science Aspirations and Careers: Age 10–14 (the ASPIRES project) is presented. In the initial phase of this project, a questionnaire exploring students' aspirations was developed, validated and trialled with nearly 300 primary school students. Principal component analyses and Cronbach's alpha revealed that the questionnaire was comprised of a number of unidimensional components and that reliability was acceptable. Further multivariate analyses indicated that students' aspirations in science were most strongly predicted by parental attitudes to science, attitudes towards school science, self-concept in science, images of scientists and engagement in science-related activities outside of school. Moreover, 'Asian' students appeared to exhibit a highly positive set of attitudes towards science and aspirations in science, particularly when compared with White students. Reasons for this observed difference are also explored.

KEY WORDS: minority ethnic students, paradox, science aspirations

Introduction

Science Aspirations and Science Careers

There has been substantial concern in many countries about students' engagement with school science and about the low numbers choosing to pursue the study of science. Indeed, this is a matter of considerable concern amongst policy makers in the UK (Roberts, 2002; HM Treasury, 2006), across Europe (European Commission, 2004) and in the USA (National Academy of Sciences 2005), and a considerable body of evidence now exists highlighting how, compared to other school subjects, science does not succeed at engaging the majority of young people (Jenkins & Nelson, 2005; Lyons, 2006; Osborne & Collins, 2001; Sjøbeg & Schreiner, 2005).

Research has demonstrated, however, that the majority of young people do have positive attitudes to science at age 10 (Murphy &

Beggs, 2005) but that this interest declines sharply in the following years (Osborne, Simon & Collins, 2003). By age 14, most children's attitudes towards science have become well established, with ever diminishing numbers choosing to study science subjects at higher levels. Indeed, Ormerod & Duckworth (1975) devoted a whole chapter of their review on attitudes to science to the considerable body of work which showed that interest in science-based careers is a product of student experiences before age 14. A more recent confirmation of this finding has been the longitudinal analysis of Tai, Liu, Maltese & Fan (2006) of National Assessment of Educational Progress (NAEP) data between 1988 and 2000 which showed that attitudes were likely to be formed by age 14. Further evidence that children's life-world experiences prior to 14 are the major determinant of any decision to pursue the study of science comes from a survey by the Royal Society (2006) of 1,141 science, engineering and technology practitioners' reasons for pursuing scientific careers. It found that just over a quarter of respondents (28%) first started thinking about a career in science, technology, engineering and mathematics (STEM) before the age of 11 and a further third (35%) between the ages of 12 and 14. Likewise, a small-scale longitudinal study that followed 70 Swedish students from grade 7 (age 12) to grade 11 (age 16) (Lindahl, 2007) found that their career aspirations and interest in science were largely formed by age 13. Lindahl concluded that engaging older children in science would become progressively harder.

Major reviews of students' attitudes towards science have been conducted by Omerod & Duckworth (1975), Gardner (1975), Schibeci (1984) and Osborne et al. (2003). Yet relatively little work has been conducted on what views young students (that is children under the age of 11) hold about science—particularly not from a perspective that understands learning as tied to processes of identity construction (Holmes, 2000) nor from an exploration of how these vary with ethnicity. This paper, which includes a focus on the experiences of pupils of British Pakistani and British Bangladeshi heritage in London schools, therefore offers new perspectives on an enduring issue for the field of science education.

Ethnicity, Aspirations and Achievement in Science

Research conducted to date has suggested that there may be an important link between the early formation of aspirations for science-based careers and later propensity to study science at higher levels and/or enter a science career. For instance, Tai et al. (2006) point to how early science aspirations are a better predictor of studying science than levels of achievement. Their US research found that students expressing expectations for a science career in their younger years are three times more likely to gain degrees in physical science and engineering than those without similar expectations. However, this close link between attitudes/aspirations and progression to study science at higher levels does not necessarily translate in a straightforward manner for all ethnic groups, particularly in the case of students of Black Caribbean, Pakistani and Bangladeshi heritage in the UK (Elias, Jones & McWinnie, 2006).

Since the 1980s, research has suggested that there may be something distinctive about the attitudes and engagement of students from South Asian backgrounds in British schools. Attention was drawn to a so-called ‘Asian effect’, describing the particularly high interest and achievement in science that was recorded amongst ‘Asian’ students. For instance, in her analysis of data from the Girls Into Science and Technology project, Kelly (1988) highlights ‘the consistently positive scores of Asian boys’ and that:

> They expressed more liking for science and more interest in learning about physical science than other pupils and they achieved better in science examinations at 16 plus. This last finding is particularly impressive as Asian boys had less science knowledge than white boys on entry to secondary school. They seem to be more successful learners of science in school than other pupils (Kelly, 1988, p. 124)

In more recent years, a considerable body of work has emerged suggesting that analysis conducted using the category of ‘Asian’ hides important differences within and between ethnic and religious groups who fall under the broad umbrella of ‘Asian’ (e.g. Abbas, 2004; Archer, 2003; Gilborn, 1990). In particular, there are striking differences between the engagement and achievement of those students of Indian (and Chinese) heritage (who tend to be higher achieving within the UK education system) and those of Pakistani/Bangladeshi heritage (who tend to be lower-achieving). Indeed, such work has identified not only differences in attainment and progression but in the ways in which these different groups of students are discursively positioned differently within educational discourse as (British Indian) ‘achievers’ versus (predominantly Muslim) British Pakistani and Bangladeshi ‘believers’ (Gilborn, 1990), ‘failures’, (Abbas, 2004) or ‘problems’ (Archer, 2003).

This pattern of differential achievement and post-16 progression between British Indian and other ‘Asian’ students continues to be confirmed by recent national examination results (Department for Children, Schools and Families, 2008) and is similarly reflected by differential rates of attrition from science’s ‘leaky pipeline’ (Elias et al., 2006; Jones & Elias, 2005). As Elias et al. discuss, minority ethnic students of Indian (and Chinese) heritage achieve more highly and are more likely to progress to study science at higher levels than those from Black Caribbean, Pakistani and Bangladeshi heritage backgrounds.

The interesting point to note within this picture, however, is that whilst all minority ethnic groups generally report high educational (and science) aspirations[1], the link between aspirations and attainment/participation in science only appears to hold true for those from Indian and Chinese backgrounds. In contrast, Pakistani and Bangladeshi heritage pupils appear to experience what Mickelson (1990) calls the ‘attitude–achievement paradox’. That is, they appear to express very high aspirations (especially compared to White, majority ethnic students), but their rates of attainment and progression in science do not match their high aspirations. This finding marks a departure from the more general relationship between aspirations and attainment/progression noted earlier by Tai et al. (2006).

For instance, Strand & Winston’s (2008) study of educational aspirations amongst inner-city pupils in England showed that 90% of British Pakistani pupils aspired to post-compulsory education. However, government statistics (DCSF, 2008) indicate that only 40% of British Pakistani pupils achieved the benchmark standard in the General Certificate of Secondary Education, suggesting a potential gap between aspirations and achievement. Analysis by Elias et al. (2006) also demonstrates how, in relation to the White population, British Pakistani and Bangladeshi students (along with Black Caribbean students) are proportionately under-represented in the number of ‘potential Physics undergraduates’ (i.e. those with sufficient and appropriate grade points to be eligible for entry to a physics degree programme).

In this paper, we draw on survey data from the ASPIRES project to map out issues pertaining to the development of children’s science aspirations over time. This project, funded by the Economic and Social Research Council, is a 5-year study in the UK that will provide longitudinal data on the factors shaping the educational and science choices and aspirations of children between ages 10 and 14. The study aims to explore how educational and occupational aspirations are formed, how aspirations are influenced by peers, parents and experiences of school science and how they are shaped by gender, class and ethnicity. These questions will be investigated both qualitatively (repeat interviews over 4 years with 60 students and parents) and quantitatively (via a national online questionnaire survey, with the first phase involving approximately 9,000 year 6 (age 10) students in Autumn 2009, who will then be tracked and surveyed again at ages 12 and 14). Whilst both the wider project and the survey data reported in this paper are broadly concerned with investigating the ways in which children's aspirations and engagement with science are shaped by identities and inequalities of 'race'/ethnicity, social class and gender, there is not a specific focus on 'Asian' students. Nevertheless, in order to ensure that factors such as ethnicity (specifically minority ethnic backgrounds) are considered, the project has deliberately sought to ensure that substantial proportions of minority ethnic students participate in the various forms of data collection. In this paper, we discuss the development of our questionnaire instrument which was designed to survey the interests of young people, age 10/11, in science and science-related careers and to identify whether there were distinctive features (such as ethnic background) correlated with the aspirations they expressed. Two hundred ninety-eight children took part in a pilot of the survey, and the findings are presented beneath and discussed in light of existing literature and their possible implications for educational policy. Whilst the size of our sample and its selection mean that any claims to wider validity must be viewed with circumspection, this article offers the reader two features of interest. First, we report the construction of an instrument and its validity which may be of value to others working in this field. Second, even within this data set, there are distinctive features within the data which merit reporting and an exploration of the issues that they raise.

Method

Questionnaire Construction

The development of the questionnaire instrument used in the quantitative phase of this research proceeded in an iterative fashion, initially by drawing on existing instruments, an extensive body of qualitative literature and data gathered from six discussion groups with year 6 pupils. These discussion groups are described in detail elsewhere (Archer, DeWitt, Osborne, Dillon, Willis & Wong, 2010), but comprised students from four London schools who varied widely by socioeconomic status, gender and ethnicity. The discussions focused on students' views and experience of science, in school and out. They also explored students' educational and occupational aspirations, as well as their images of scientists.

Perspectives informing the questionnaire were also provided by literature on attitudes to science (e.g. Baker & Leary, 1995; Cleaves, 2005; Krogh & Thomsen, 2005; Miller, Blessing & Schwartz, 2006; Osborne et al., 2003), feminist theorisations of science and identity (e.g. Brickhouse & Potter, 2001; Calabrese, Barton & Brickhouse, 2006; Carlone, 2004; Carlone & Johnson, 2007), psychological theories of self-efficacy (e.g. Bandura, Barbaranelli, Caprara & Pasrorelli, 2001; Britner, 2008; Zeldin & Pajares, 2000) and self-concept in science (e.g. Beghetto, 2007; Murphy & Whitelegg, 2006) and research on career and occupational choices (e.g. Chaves, Diemer, Blustein, Gallagher, DeVoy, Casares & Perry, 2004; Ferry, Fouad & Smith, 2000; Lent, Brown & Hackett, 1994, 2000; Turner, Steward & Lapan, 2004).

One of the criticisms of work in this domain is that many instruments used to measure attitudes towards science are not based on clearly defined constructs (Blalock, Lichtenstein, Owen, Pruski, Marshall & Toepperwein, 2008; Kind, Jones & Barmby, 2007). Such lack of clarity creates ambiguity about what such instruments are actually intended to measure, which undermines the validity of the work.

In order to establish construct validity, all of our constructs were theoretically grounded. For instance, previous research indicates the influence of familial relations and parental attitudes towards science on students' attitudes and aspirations in science (c.f. Baker & Leary, 1995; Gilbert & Calvert, 2003; Gilmartin, Li & Aschbacher, 2006). Other studies highlight the importance of images of scientists for students' choices and aspirations (c.f. Bennett & Hogarth, 2009; Cleaves, 2005; Miller et al. 2006). Still other research reflects the influence of students' experience of school science (Carlone, 2003, 2004; Cleaves, 2005; Osborne et al., 2003) and of self-concept in science (Beghetto, 2007; Murphy & Whitelegg, 2006). The constructs incorporated into the initial draft of the questionnaire (prior to piloting with students) included the following: cultural capital, interest in science outside of school, occupational values, parental ambitions or expectations, parental attitudes towards science, parental involvement, peer attitudes to school and to school science, images of scientists, perceptions of school science, self-concept in science, self-efficacy in science and future aspirations in science. All of these have a well-established empirical or theoretical base. Space, however, does not permit their full elaboration here.

Another focus of the critique of instruments used to measure attitudes towards science is the weakness of some of their psychometric properties (Blalock et al., 2008; Germann, 1988; Kind et al., 2007; Owen, Toepperwein, Marshall, Lichtenstein, Blalock, Liu, Pruski et al., 2008). Reports on many of the instruments used do not include measures of internal consistency and/or unidimensionality of scales. Furthermore, sometimes these analyses do not seem to have been conducted at all. In the case of this research, time did not permit the construction of entirely new scales. Rather, existing instruments that had been previously tested and validated were drawn upon in creating items for our pilot questionnaire. These measures were drawn from 'What do you think of science' (Kind et al., 2007); the Simpson–Troost Attitude Questionnaire—Revised (Owen et al., 2008); Sources of Science Self-Efficacy scale (Britner, 2008); the Relevance of Science Education (ROSE) questionnaire (Schreiner & Sjøberg, 2004) and 'Is Science Me?' (Gilmartin et al., 2006). Nevertheless, there were some constructs and items of interest for which existing instruments were not sufficient, such as measures of cultural capital, perceptions of scientists and some aspects of parental involvement. Thus, drawing on the qualitative literature as well as discussion groups with year 6 students[2], additional scales and items were developed and the data presented here offer some analysis of their validity and reliability. Finally, it should also be noted that the discussion groups were also used to test the wording and formatting of various items, particularly those concerning parental occupation and ethnicity.

To establish psychometric validity of our instrument more precisely, principal component analyses (PCA) and measures of internal consistency (such as Cronbach's alpha) were carried out on our pilot data in order to refine our scales (described later). Principal component analysis has the purpose of identifying resolvable components, and validity is supported when these components can be interpreted meaningfully in light of the literature from which the constructs were initially derived.

Participating Students and Schools

Two hundred ninety-eight students in years 5 and 6 (ages 10–11) from four schools completed the pilot version of the questionnaire, and these responses were used to assess the unidimensionality and internal consistency of the instrument. Although the survey itself was intended for year 6 students, the timing of the pilot (in late June, towards the end of the school year) meant that it was sensible to include not just year 6 students but year 5 students as well because they were closer in age to those who would take the questionnaire (in the autumn of year 6). Their inclusion gave a more accurate picture of the appropriateness of the reading level and intelligibility of the items for students who would be beginning year 6. The four schools were all located in London but varied in terms of ethnicity, social class, neighbourhood environment, size and type. They were recruited via personal contacts, but the variation was intended to ensure that we had a spread of students, in order to increase the possibility that the final version of the questionnaire would be as comprehensible as possible and could be completed within a reasonable time by a range of students (given the small sample size, no attempts to generalise from the sample will be made). Table 1 summarises information about the students and schools. It should be noted that the paper questionnaire that was used on this occasion only required students to indicate their ethnic background at the broadest level of descriptor, namely 'White', 'Black', 'Asian', 'Chinese' or 'other' (e.g. mixed). Obviously there are numerous problems associated with the use of such crude and broad-brush ethnic categories, not least given the critiques of terms such as 'Asian', as discussed earlier. Subsequent versions of the questionnaire have been online and have used the greater flexibility of the medium to offer a range of more detailed and specific ethnic categorisations to students. However, this initial paper-based questionnaire used the most simplistic version for two main reasons: First, more detailed versions of the question were being separately and simultaneously trialled and second, early trials of ethnic categorisation questions had indicated that presenting a more detailed set of options to this age group was experienced as being too 'confusing' and too much to read on the printed page. Subsequent online versions of the question have thus utilised a structured approach to presenting the various options available. The full version of the questionnaire was administered online, and its functionality enabled a more detailed specification and probing of specific ethnic backgrounds. However, based on informa-

TABLE 1

Characteristics of participating students and schools

School name[a]	*Description*	*Gender (participating students)*	*Year group*	*Ethnicity*
Beech Primary	Urban school with approximately 30 pupils per year. Located in an area of very high deprivation, including refugee housing, approximately 70% of students are eligible for free school meals. Most students do not have English as their home language	12 girls, 13 boys	25 year 6 (0 year 5)	4 Black, 2 White, 17 Asian
Lamar Junior School	Large, diverse urban school, years 3 through 6, with approximately 120 pupils per year. Approximately 90% speak English as an additional language and over 40% are eligible for free school meals	87 girls, 77 boys	81 year 5, 83 year 6	12 Black, 16 White, 122 Asian, 14 other
St Michael's Roman Catholic Primary	Small primary school with around 25 students per year group. Located in a deprived area, but parents must go through an application process to ensure a place. Approximately 30% of pupils are eligible for free school meals and around 75% are ethnic minorities	32 girls, 19 boys	23 year 5, 28 year 6	20 Black, 21 White, 3 Asian, 7 other
Riverdale Prep	Private school, with students in nursery through year 8, approximately 100 students per year (in years 3–8). Parents must pay tuition fees which are quite substantial	31 girls, 27 boys	27 year 5, 31 year 6	1 Black, 43 White, 9 Asian, 5 other[b]

[a]All school names are pseudonyms

[b]In this table, 'other' includes mixed race children, as well as the two pupils of Chinese origin at Riverdale Prep (there were no other students of Chinese origin)

tion provided by the schools, it can be estimated that 75–80% of the 'Asian' sample are of Bangladeshi or Pakistani heritage (and this rises to 80–100% for students from Lamar and Beech). We recognise that the terminology we use here to describe these 'Asian' students is necessarily provisional and problematic, and hence, we use the term 'Asian' here (in scare quotes) as a shorthand to signal this provisionality and to alert the reader that whilst our analyses of 'Asian' students report predominantly to those of British Pakistani and Bangladeshi backgrounds, there is some variability within the sample with regard to precise cultural, ethnic and religious backgrounds.

Analysis

Analysis of questionnaire data proceeded in two stages. First, reliability and validity analyses were carried out, in order to refine the questionnaire and determine which items to drop. Second, multivariate analyses utilised the latent variables (components) that emerged from the first set of analyses to explore patterns in children's responses, particularly with regard to gender and ethnicity, and to investigate what components may be contributing to students' aspirations in science.

Unidimensionality and Internal Consistency. PCA was utilised to identify the underlying dimensions, or components in the data. Each component is comprised of individual items, which can be scored for each respondent in order to create a latent variable that corresponds to the underlying dimension, or component. PCA is a variant of factor analysis which is psychometrically sound and identifies the unidimensional components within our scales (Field, 2009)[3]. Using PCA with orthogonal rotation (varimax) on the questionnaire responses, 18 components emerged, 15 of which were retained (the three that were dropped were generally comprised of items that were not understood by the students). Drawing on our knowledge of the literature, the components that were retained were identifiable as aspirations in science, interest in science outside of school, parental support/involvement, parental aspirations, parental attitudes to science, peer orientation to school and attitudes to science, experience of (or attitudes towards) school science, self-concept in science (positive and negative), images of scientists (positive and negative) and components related to possible future jobs and careers. These empirically derived or validated constructs (including their constituent items) mapped very closely onto the initial theoretically derived constructs in the questionnaire (which had drawn upon previous research, both qualitative and quantitative, as described above).

Both the principal component analysis and Cronbach's alpha were used to determine which items (within the components) to drop from the questionnaire. More specifically, items with factor loadings under 0.5 or that lowered the reliability of the scale (as measured by Cronbach's alpha) were usually dropped. Of the components that remained in the final questionnaire, the factor loadings of individual items on their respective components ranged from 0.417 to 0.897, with most being above 0.600. In addition, Cronbach's alpha for each component ranged from 0.512 to 0.869, with seven (of 15) components having alphas of 0.7 or higher. The factor loadings, along with the Cronbach's alpha for each component, can be found in the "Appendix". It should be noted that although alphas of 0.7 are considered acceptable levels of internal consistency, lower alphas are not unusual for attitude scales or other psychological constructs (Field, 2009), particularly in surveys with younger children. In addition, alpha can be lowered by having a small number of items (and five of our components were comprised of three or fewer items). However, there was a need to balance the increased reliability that would have been provided by including more items with the importance of a questionnaire that was not overly long. Hence, somewhat lower figures were considered acceptable. Moreover, as noted previously, the constructs that emerged from the PCA and were retained mapped very closely to those that had been abstracted from the literature (and previous research). In light of their validity from that perspective (and the need to have some sort of measure of these constructs in the questionnaire), we decided to retain these components with reliabilities lower than 0.7. It may also be of note that three scales with the lowest reliabilities pertain to characteristics of future jobs, an area in which children's opinions shift frequently and are likely to be unreliable at this age.

A few items were also dropped because they were each felt to be very similar to another item and their removal did not affect the reliability (as measured by Cronbach's alpha) of a scale or the unidimensionality (as determined by PCA) of the remaining items. Given the age and likely attention span of participating students and the need not to place too many demands on the time of teachers and schools, the questionnaire had to be reasonably short. In addition to dropping items, modifications were also made to the wording of some items when it was apparent that students were struggling with the question. For instance, an item enquiring about numbers of friends liking science was modified after discussion with some students. A final version of the questionnaire, which has since been distributed online, is available in Word format from the authors.

Other Analyses. Following modification of the questionnaire, multivariate analyses were used to explore patterns in the data by gender and ethnicity. Relations between various components (such as interest in science) and aspirations in science were also investigated. In conducting the analyses, questionnaire items were used to create latent variables that corresponded to each component. Items were scored from 1 (strongly disagree) to 5 (strongly agree) to create a score for each child on each latent variable (scoring was adjusted to compensate for negatively worded items). These scores were then used as dependent variables in the analyses. More specifically, regression analyses (backward method) were used to explore the relations between aspirations in science, the other latent variables identified by the PCA and the categorical variables of gender and ethnicity. Next, univariate analyses (ANOVAs and Kruskal–Wallis tests) were used to identify whether students' responses on the various latent variables (especially those that predicted aspirations in science) differed by gender or ethnicity. Generally, Kruskal–Wallis tests, which are non-parametric and use the H statistic, were used instead of ANOVAs (which use the F statistic) because distribution of scores on the latent variables was not sufficiently close to the normal curve. Finally, where significant differences were found, post hoc Bonferroni tests were used to identify differences between specific pairs of groups (e.g. 'Asian' students and White students).

Findings

Aspirations in Science

The primary research question of the ASPIRES project concerns students' aspirations in science and factors that may be related to the aspirations they express. Whilst the aspirations students express in years 5 and 6 are quite likely to change as they grow older, it is important to have a baseline for comparison with aspirations students hold later in the study. Our first finding was that nearly 50% of students agreed or strongly agreed that they would like to study more science in the future, but noticeably fewer agreed that they would like to have a job that uses science (33%) or would like to become a scientist (20%). This pattern is congruent with previous research indicating that although students may enjoy science—and may want to study it further for a variety of reasons—they are less likely to envision themselves as becoming scientists (c.f. Bennett & Hogarth, 2009; Caleon & Subramaniam, 2008; Jenkins & Nelson, 2005).

But what factors are related to aspirations in science? Regression analyses indicated that the following latent variables were the strongest predictors of student scores on the aspirations in science variable: parental attitudes to science ($\beta = 0.322$), (positive) self-concept in science ($\beta = 0.289$), interest in science outside of school ($\beta = 0.119$), experience of school science ($\beta = 0.111$) and (positive) images of scientists ($\beta = 0.095$; students' scores on these six latent variables are summarised in Table 2). Moreover, when gender and ethnicity were added into the analysis, these same five latent variables emerged as the main predictors, along with the 'Asian' ethnic classification ($\beta = 0.125$). These six variables all contribute significantly to aspirations in science (as reflected in scores on this latent variable). All six predictors (the five latent variables and being 'Asian') were significant at $p < 0.05$ and adjusted $R^2 = 0.546$, meaning the regression model accounts for 54.6% of the variance in students' aspirations in science. It should be noted here that 'predict' in this context refers to correlations between independent (or 'predictor') and dependent variables and should not be taken to imply causality.

TABLE 2

Student scores on latent variables

Latent variable	*Mean*	*Standard deviation*	*Maximum range of possible scores*
Aspirations in science	11.83	3.988	4–20
Parental attitudes to science	10.91	2.595	3–15
Attitudes towards school science	11.35	2.75	3–15
Self-concept in science	18.50	3.82	6–25
Images of scientists	19.80	3.11	7–25
Interest in science outside of school	14.75	4.81	5–25

N.B. Variables concerning parents reflect student perceptions or reports of these attitudes. In addition, high scores are positive, reflecting high aspirations, positive attitudes, high expectations and so forth

As noted in the methods section, univariate analyses were also used to look more closely at group differences in aspirations in science (and at other latent variables contributing to these aspirations). As reflected in Table 3, it appears that aspirations in science were significantly affected by ethnicity ($H(4) = 32.24$, $p < 0.001$)[4]. In addition, 'Asian' students had significantly higher aspirations than Black ($p < 0.05$) and White ($p < 0.001$) students. Finally, although boys expressed slightly higher aspirations in science than girls, these differences were not significant.

Latent Variables Correlated with Student Aspirations in Science

The regression analysis described in the previous section identified a number of latent variables as significant predictors of student aspirations in science. In addition, students' aspirations in science differed by ethnicity. Further analyses explored whether this pattern held for individual latent variables that were correlated with aspirations in science.

As reflected in Tables 3 and 4, student scores differed by ethnicity on all but one of the latent variables connected with aspirations in science. In these cases, post hoc Bonferroni tests were used to identify more specific differences, and these pairwise comparisons revealed that, in most cases, 'Asian' students were more inclined towards science than were White students. These differences are described in more detail below (students did not differ by ethnicity on the latent variable of interest in science outside of school).

Parental Attitudes to Science. The distribution of scores on this variable is quite strongly skewed in a positive direction, suggesting that students perceived their parents as having generally positive attitudes towards science. However, fewer students agreed or strongly agreed (36.7%) with the specific item 'My parents would be happy if I became a scientist when I grow up', compared with the other two items in this latent variable. Thus, it may be the case that although parents value science and consider it an important subject, they are less concerned about whether or not their children pursue science as a career.

Table 3 reflects that reported parental attitudes to science differed by ethnicity ($H(4) = 14.751$, $p < 0.01$). Moreover, 'Asian' students reported significantly more positive parental attitudes to science than White students ($p < 0.01$).

TABLE 3

Mean scores on latent variables by student ethnicity (SD in brackets)

	*Aspirations in science***	*Parental attitudes to science**	*Attitudes towards school science***	*Self-concept in science***	*Images of scientists***	*Interest in science outside of school*
Asian	12.95 (3.99)	11.46 (2.37)	11.85 (2.73)	19.38 (3.60)	20.33 (3.15)	14.87 (4.76)
Black	10.78 (3.53)	10.69 (2.84)	11.38 (2.29)	17.94 (3.83)	20.26 (3.07)	13.03 (5.16)
White	10.14 (3.57)	10.17 (2.60)	10.27 (2.73)	16.83 (3.59)	18.61 (2.82)	14.81 (4.77)
'Other'	12.33 (4.00)	10.56 (2.99)	11.76 (2.86)	19.50 (4.2)	20.00 (3.04)	16.56 (4.35)

*Groups differed on this latent variable, $p < 0.01$; **Groups differed on this latent variable, $p < 0.001$

TABLE 4

Mean scores on latent variables by gender (SD in brackets)

	Aspirations in science	*Parental attitudes to science*	*Attitudes towards school science*	*Positive self-concept in science*	*Positive images of scientists**	*Interest in science outside of school*
Girls	11.63 (3.88)	11.06 (2.54)	11.42 (2.75)	18.46 (3.76)	19.41 (3.17)	14.73 (4.65)
Boys	12.08 (4.12)	10.73 (2.66)	11.27 (2.76)	18.54 (3.91)	20.26 (2.99)	14.78 (5.00)

*Groups differed on this latent variable, $p < 0.05$

Experience of (or Attitudes Towards) School Science. This variable focuses on students' experience of school science lessons (such as whether they are interesting and exciting). Some students expressed quite negative attitudes towards school science, but encouragingly, the distribution of scores on this variable was positively skewed, meaning most students were generally positive about school science. However, there was a significant difference in attitudes to school science by ethnicity ($H(4) = 21.062$, $p < 0.001$). As with perceived parental attitudes to science, 'Asian' students had significantly more positive attitudes towards school than White students ($p < 0.001$).

Of particular interest at this point is the individual item 'Studying science is useful for getting a good job in the future'. Although the PCA did not identify it as part of the attitudes towards school science latent variable, it is of interest because of previous research indicating that students' perceptions of the usefulness of school science can influence aspirations in science and decisions about whether to continue studying science (Miller et al., 2006; Springate, Harland, Lord & Wilkin, 2008; Vidal Rodiero, 2007). Consequently, this item was examined independently. As might be expected from the two latent variables described above, students' perception of the utility of school science differed by ethnicity ($\chi^2 = 34.46$, $p < 0.001$). Moreover, 'Asian' students perceived studying science to be more useful than did White students.

Self-Concept in Science. Previous research indicates that self-concept in science, or how 'good' students perceive themselves to be in science, is an important predictor of aspirations in science or decisions to pursue further study of science (Bandura et al., 2001; Blenkinsop, McCrone, Wade & Morris, 2006; Cleaves, 2005; Murphy & Whitelegg, 2006; Zeldin & Pajares, 2000). In the current study, most students expressed a fairly positive self-concept in science.

As Table 3 shows, students' self-concept in science differed by ethnicity ($F(4) = 7.015$, $p < 0.001$), with 'Asian' students expressing more positive self-concepts than White students ($p < 0.001$).

Images of Scientists. Previous research also suggests that decisions to pursue science are influenced by how individuals perceive scientists and the extent to which they consider work in science to be the kind of work they might want to pursue (Bennett & Hogarth, 2009; Brown, 2006; Buck, Cook, Quigley & Eastwood, 2009; Gilbert & Calvert, 2003; Jones, Howe & Rua, 2000; Springate et al., 2008). Encouragingly, students in this study tended to have quite positive perceptions of scientists overall.

Tables 3 and 4 highlight significant effects of ethnicity ($H(4) = 20.14$, $p < 0.001$) and gender ($H(1) = 5.733$, $p < 0.05$). Again, ‘Asian’ students differed significantly from White students in the extent to which they perceived scientists in a positive light ($p < 0.01$).

Discussion

In light of the small sample size and the lack of a fully representational sample, all findings and analyses need to be treated as tentative and provisional. Certainly, we make no claims for our data or analyses being representational or generalisable. However, we would suggest that our data point to some interesting provisional themes which challenge and extend what is already known about minority ethnic students’ aspirations and that are worthy of discussion and might be fruitful for informing future work.

The most striking finding to emerge from our data contains echoes of the ‘Asian effect’ noted previously by Kelly (1988). Namely, the ‘Asian’ students appeared to exhibit a highly positive ‘package’ of attitudes, expectations and behaviours that all combine to foster a strong interest and engagement in science:

- ‘Asian’ students are more likely to want a job in science and/or to become a scientist than White students (and Black students)
- ‘Asian’ students’ parents have more positive attitudes to science than White students’ parents
- ‘Asian’ students see studying science as more useful for getting a job in the future than do White students
- ‘Asian’ students have a more positive self-concept in science than White students
- ‘Asian’ (and Black and other ME) students have more positive views of scientists than White students
- ‘Asian’ students (and minority ethnic students in general) report higher parental expectations (for school marks, jobs and career ambitions) than White students
- ‘Asian’ students report higher peer orientations to school than White students

- ‘Asian’ students’ parents are positively involved in their children’s schooling, as are parents from all other ethnic groups

Perhaps the most striking and immediate analysis that might be made of these findings is that they appear to strongly contradict the picture portrayed by mainstream New Labour educational policy, namely that the ‘problem’ of low achievement and post-compulsory educational progression amongst minority ethnic students (such as the British Pakistanis and Bangladeshis) is due to a culture of low aspirations (a ‘poverty of aspiration’) amongst such families. For instance, the 2005 UK government educational strategy paper talks specifically of the need for ‘stretching the aspirations’ of minority ethnic groups (Department for Education and Skills DfES 2005; para 4.4).

The second point we would wish to draw attention to in our analysis would be that given the overwhelmingly positive nature of the ‘Asian’ students’ ‘package’ of science attitudes, aspirations and behaviours, we might reasonably expect them to continue into science ‘careers’ (in the broadest possible sense, e.g. studying to post-compulsory levels), as per Tai et al. (2006). However, as outlined in the introduction, statistics to date would indicate that this tends not to be the case. This raises the question as to why this highly positive attitude does not appear to translate through the science education pipeline into higher education and beyond. Whilst this anomaly may be due to methodological issues within the survey sample and design (or the cohort of young people surveyed may be somehow exceptional), we offer the following interpretation.

Whilst our findings indicate that Pakistani and Bangladeshi parents (like parents from White and minority ethnic backgrounds) were involved in their children’s education, research has suggested that some minority ethnic families may be disadvantaged in terms of being able to translate their involvement into symbolic cultural capital—i.e. into a form that is able to operate effectively within the sphere of mainstream education to promote ‘traditional’ forms of academic success. For instance, Blackledge (2001) discusses how Bangladeshi mothers may engage in educational activities such as reading to their children but that where this is in Bengali and/or restricted to Bengali cultural texts, it does not necessarily translate into mainstream educational advantages for the child (whilst being valuable in its own right, e.g. for linguistic and cultural reasons). Indeed, the 'Asian' students in our sample recorded lower levels of cultural capital than did White students.

The literature also suggests that minority ethnic, working-class families may not enjoy the same levels of resource to fund and promote their children's achievement through provision of extra-curricular activities (Archer & Francis, 2007). They also experience less productive relationships with schools (Crozier & Reay, 2005) and may not have access to the sorts of social and cultural capital that can support and produce high academic achievement (Reay, 1996).

The issue of social and cultural capital may also play a role in curtailing the range of career paths that are known about and considered accessible. For instance, evidence indicates that minority ethnic families may tend to encourage their children to follow particular known 'safe' routes to employment, namely those that they know others 'like us' have followed and succeeded in (Archer & Francis, 2007). This can operate as a pragmatic strategy for promoting success within an environment of multiple inequalities. In the case of British Pakistani and Bangladeshi families and science careers, research by Smart & Rahman (2009) indicates that whilst Bangladeshi girls report having strong parental support for high aspirations, with biology, chemistry and maths particularly positively perceived as routes into valued professional careers such as pharmacy, there was little knowledge of potential careers (and hence interest or support) for physical sciences, engineering and technology.

It is also pertinent to note that working-class, minority ethnic families are more likely to attend urban, multi-ethnic schools in deprived areas. Such schools not only often experience more pressures on their resources and physical/material environments but also suffer from disproportionately high teacher attrition, especially (at secondary level) within science (Manning, 2009).

Finally, the literature indicates how racism and other inequalities can curtail the aspirations and achievement of minority ethnic pupils. These factors can operate on two main levels: firstly, in disadvantaging minority ethnic individuals within educational institutions through, for instance, the particular racialised ideologies that educators may hold of different groups of students (see Archer & Francis, 2007 for an overview of how such views are subtly yet distinctly configured for different ethnic groups) and, secondly, through the perceived dominant culture of science, which might exclude particular groups of students (Aikenhead, 1996; Baker, 1998; Harding, 1986). For instance, it has been argued that the popular stereotype of 'the scientist' continues to be configured as someone White, male and middle class (AAAS, 1998), which could be discouraging to some minority ethnic students (Ong, 2005), but especially those from under-represented minority groups (e.g. Black Caribbean).

All of the above suggest that the focus within UK education policy over the last decade on 'raising' aspirations amongst minority ethnic groups as the means for improving achievement and post-16 progression (including into science) is flawed. As detailed by Archer and Francis (2007), UK education policy under the New Labour administration addressed the issue of underachievement amongst minority ethnic groups as resulting from a poverty of aspirations amongst minority ethnic families and communities—hence, a range of initiatives have been proposed with the goal of 'raising' aspirations amongst target groups. This focus on raising aspirations looks set to continue under the new Conservative–Liberal alliance at the time of writing. It would seem from our analyses, however, that the issues underlying the aspiration–achievement paradox (Mickelson, 1990) will require support and intervention at a structural level. In the case of British 'Asian' students, this would appear to be an important and worthwhile endeavour, not least so as to capitalise on the potential of the highly favourable 'package' of attitudes, aspirations and behaviours reported here. We might thus postulate that a change in policy focus is required—parental and pupil attitudes and aspirations are not in need of 'raising'—it is rather the surrounding context and conditions that need to be addressed. One potential way in which this might occur could be through targeted support to help minimise the aspirations–achievement gap within particular communities where there are existing high aspirations and positive views of science but where achievement tends to lag behind. This might also be coupled with support aimed at widening knowledge of the range of career opportunities afforded by science, so that aspirations (and understanding of how these aspirations might be attained) might be broadened beyond the confines of existing 'known, safe routes' (Archer & Francis, 2007).

The forthcoming phases of our study offer an opportunity to develop further upon the tentative themes raised here. We plan to track the engagement and participation of a wide range of students as they progress through school, investigating the interplay of factors such as those outlined, on their aspirations and engagement with science. The research being undertaken by Wong on the science aspirations of 11–14-year-old minority ethnic pupils will also enable a specific focus on understanding the issues underpinning minority ethnic students' engagement with science and phenomena such as the science aspirations–achievement paradox.

APPENDIX

TABLE 5

Summary of rotated factor loadings for components in pilot questionnaire

Item	*Aspirations in science*	*Interest in science outside of school*	*Positive images of scientists*	*Negative images of scientists*
I would like to study more science in the future.	0.822			
I would like to have a job that uses science.	0.875			
I would like to become a scientist.	0.871			
I think I could be a good scientist one day.	0.822			
Do science activities (e.g. science kits, nature walks) outside of school (how often?)		0.692		
Read a book or magazine about science		0.767		
Visit web sites about science		0.737		
Visit a science centre, science museum or zoo		0.578		
Watch a TV programme about science		0.679		
(Scientists and engineers) can make a difference in the world.			0.639	
Make a lot of money			0.645	
Have exciting jobs			0.692	−0.365
Are brainy			0.643	
Are respected by people in this country			0.641	
Are odd				0.751
Spend most of their time working by themselves			(0.342)	0.547
Do not have other interests				0.781
Cronbach's alpha	0.869	0.729	0.681	0.541
Item	*Parental support/involvement*	*Parental ambitions*	*Parental attitudes to science*	*Peer attitudes to science*
It is important to them (family) that I try my best in school.	0.727			
They know how well I am doing in school.	0.775			
They always attend parents' evenings at school.	0.683			

It is important to them that I get good marks in school.		0.696		
They expect me to go to university.		0.539		
They want me to get a good job when I grow up.	0.421	0.663		
They want me to make a lot of money when I grow up.		0.788		
My parents think science is interesting.			0.817	
My parents think it is important for me to learn science.		(0.310)	0.728	
My parents would be happy if I became a scientist when I grow up.			0.776	
How many of your close friends like science?				0.829
Think science is cool?				0.897
Cronbach's alpha	0.578	0.648	0.704	0.707

Item	*Peer orientation to school*	*Experience of school science*	*Self-concept in science (positive)*	*Self-concept in science (negative)*
How many of your close friends get good marks in science?	0.568			
Care about their marks in school?	0.731			
Encourage you to do well in school?	0.671			
Are brainy?	0.716			
We learn interesting things in science lessons.		0.771		
I look forward to my science lessons.		0.879		
Science lessons are exciting.		0.864		
Science is one of my best subjects.		0.583	(0.315)	(0.366)
My teacher expects me to do well in science.			0.698	
I get good marks in science.			0.704	
I learn things quickly in science lessons.			0.534	(0.451)
I understand everything in my science lessons.			0.557	(0.375)
If I study hard, I will do well in science.			0.608	
I do well in science.			0.596	
I find science difficult.				0.829
I am just not good at science.				0.775
I feel helpless in science lessons.				0.729
Cronbach's alpha	0.611	0.832	0.778	0.760

TABLE 5
(continued)

Item	*Future job—ambition*	*Future job—social*	*Future job—creating/making*
(For my future job it is important to me) to earn a lot of money	0.652		
To be my own boss	0.741		
To become famous	0.719		
To work with others instead of by myself		0.555	
To have time for hobbies and other interests		0.729	
To work with people rather than things		0.725	
To have time for a family		0.417	
To make a difference in the world			0.636
To work outdoors	(0.397)		0.574
To make, design or invent things			0.729
To build or repair things using my hands			0.570
Cronbach's alpha	0.563	0.512	0.605

N.B. These are the items that remain in the questionnaire following the initial analysis. In addition, for clarity, only factor loadings of 0.300 and higher are represented in the table (a loading in parentheses indicates that an item formed part of a different latent variable)

NOTES

[1] Indeed, even when factors such as socioeconomic status are controlled for, minority ethnic students generally report higher aspirations than comparable white students (e.g. Strand & Winston, 2008 study of 849 'inner-city' pupils in England. See also Cabinet Office, 2008; Connor, Tyers, Modood & Hillage, 2004; Strand, 2007).

[2] Forty-two year 6 students from four London schools participated in these discussion groups in spring 2009. The six groups comprised students who varied widely in terms of ethnicity, gender and social class and focused on students' views and experience of science, in school and out. The discussions also explored their aspirations for future education and possible careers.

[3] Although, strictly speaking, components are not the same as factors because they result from different analyses, the terms are often used interchangeably and we will follow this convention in this paper.

[4] The Kruskal–Wallis test, which is non-parametric, uses the H statistic, rather than the F statistic.

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