

Count me in! Gender and minority ethnic attainment in school science

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Is it females who underachieve in science or males? Why do so few females study physics A-level? What's the current picture about the attainment of minority ethnic groups in school science?

Approaches to difference

There is a large research literature on gender and educational attainment and on the educational attainment of minority ethnic pupils. Here we review this research literature for school science education and suggest possible ways forward for teachers of science.

Pupils differ with regard to a very wide range of variables including socio-economic class, gender, ethnicity, preferred learning styles, interests and abilities. Faced with such a catalogue, and a class of up to 30 pupils, it is hardly surprising that one of two tactics may suggest themselves. First, a busy teacher may rely, whether or not she or he admits it, on a handful of generalisations, such as '*Boys are more*

likely to ask questions out loud than are girls' and '*Asian pupils are less boisterous than Afro-Caribbean pupils*'. Second, the same or another busy teacher may simply strive to '*treat all pupils as individuals*'.

There is much to commend in both these approaches. There is a certain truth in many of the generalisations that teachers make about different pupil groups, even if teachers may hesitate nowadays to voice such stereotypes. And there is much to be said for treating all pupils as individuals. However, there are difficulties with both approaches. One obvious problem with the first approach is that, even if some generalisations prove valid (at least in some lessons with certain teachers) when talking about the average behaviour of members of one group compared with another (e.g. boys are more likely than girls to call out), there are almost always exceptions at the level of individuals (some girls call out more than the average boy and some boys never call out).

A related danger in the first approach is that we see pupils as members of groups and assume that they will behave as such: a typical and frequent example is that many teachers tolerate different amounts of undesired calling out and movement around the class from different categories of pupils. Some pupils (with more than a certain logic) perceive this as unfair. A related danger is that pupils start to behave as expected. If teachers expect girls to be conscientious at physical science but not to show especial flair or insight, such an expectation (from a powerful being like a teacher) shapes and may well become the reality.

ABSTRACT

There is no single 'solution' to the 'problem' of underachievement in school science by certain groups. Such underachievement is strongly connected to how society views the members of these groups. It is not enough for schools to be isolated islands of good practice: they need to help pupils to reflect critically on the world inside and outside school, and then equip them with the necessary tools to deal with this world. A number of strategies are suggested for use in schools to help those from groups that often underachieve to get more from their science lessons.

Trying to treat each pupil as an individual, however, also holds dangers: a busy teacher with a large number of pupils may become swamped and end up treating pupils inequitably, more or less in relation to pupil demand. There is much to be said for pupils setting the agenda in lessons but there is much too to be said for teachers controlling the overall framework within which lessons take place. Pupils do not arrive at lessons the same as one another: quite the reverse. They arrive with years of their lives already lived, shaped by themselves, their families and the wider influences of society. The role of a teacher (and the education system as a whole) concerned with equity is not meekly to acquiesce with this state of affairs but to be prepared, where necessary, to improve it.

If we take gender, ethnicity and social class as three of the major possible variables correlating with differences in educational outcome, we find that more research is done on gender – and far more attention paid to it in the popular media – than on ethnicity or social class. There may be several reasons for this. For one thing, it is far easier (both quicker and more valid) to assign children to the categories of ‘female’ or ‘male’ than to assign them to various categories used for ethnicity and social class. In addition, categorising people by gender is seen by many as ‘safer’ (politically less problematic) than using ethnicity or social class. There is even less research into science education and social class than into science education and ethnicity. For this reason, we focus on gender and ethnicity, while at the same time hoping that some of our suggestions, if adopted, would also help reduce class-based educational inequalities.

The gender gap: choice and attainment

When pupils made option choices among the sciences in England and Wales at age 14, there was a strong tendency for girls to be more likely to choose biology and for boys to be more likely to choose physics. The National Curriculum stopped this in the state sector. To some extent, though, all that has happened is that such gender imbalance has been postponed by a couple of years. Only one in four advanced-level physics students is female. However, those young women who do take advanced-level physics now do as well at it as the young men.

At every subsequent stage of science academia and in the scientific industries, women become

progressively under-represented so that, to cite the most extreme case, currently over 99 per cent of engineering professors in the UK are male (Peters *et al.*, 2002). The reasons for the under-representation of women at senior levels and for differences in the extent of such under-representation between different disciplines are many and include rigid career structures (making it more difficult to take a couple of years out to have and bring up a young child), excessive workloads and conscious and unconscious perceptions of people about what is appropriate for women as opposed to men.

Ethnic minorities: the attainment gap

Surprisingly little UK research has been undertaken on the relationship between ethnicity and educational attainment in science. The relevant published data mostly relate to educational attainment across a range of subjects. Even here there are problems with data collection (Gillborn and Mirza, 2000). For example, over 30 per cent of local education authorities (LEAs) in England and Wales bidding for Ethnic Minority Achievement Grants (EMAGs) do not record GCSE [national examination usually taken at age 16] attainment by ethnic origin. Another difficulty is the terminology used. Although ‘black’ is still used by many as a label for themselves, many people classified by others as black do not use the term to describe themselves. The language in this area brings together issues of ethnicity, ‘race’, skin colour, country of origin, religious background and cultural identity.

Nevertheless, some safe generalisations can be made. For a start, for each of the six main ethnic groups studied by Gillborn and Mirza (2000), there is at least one LEA where that group is the highest attaining – which is encouraging (and difficult to explain on any fundamental notions of difference). On average, though, across England and Wales African-Caribbean, Pakistani and Bangladeshi pupils are markedly less likely to get five or more GCSEs at grade C or above than their white and Indian peers. Particularly notable is the progress that pupils of different ethnicities make: six LEAs in Gillborn and Mirza’s analysis provided enough data to compare progress from baseline [age 4/5] through to GCSE. In each case the African-Caribbean pupils’ position declined relative to their peers.

Research by Race on the Agenda (ROTA) on the performance of pupils in 13 LEAs in or near London

produced similar findings (Richardson and Wood, 1999), revealing a relative decline in attainment of African-Caribbean pupils between the ages of 11 and 16.

Whose story are we telling?

Despite the historical importance of female scientists and those from minority ethnic groups their story does not seem to be well represented in the school science curriculum. Nor does it ever seem to be the case that pupils consider why the few scientists they read about are mostly male and white (Reiss, 1993). Accordingly, pupils end up concluding that science is principally a white male activity:

All the scientists I've read about, they've been men really ... but I think that's because well ... women had babies – so women stayed at home and looked after the babies. (Christine, year 10)

This research (Hatchell, 1998) suggests that the female contribution to science is largely ignored. Having collected data using open-ended questionnaires, participatory observation in classrooms and in-depth interviews, Hatchell concluded that:

Most students suggested that scientists were mostly male and were unable to identify any female scientists from the past or present.

The absence of personal experience

I'll understand a sort of basic principle that doesn't really fit anything that I will encounter in my entire life! (girl in Hughes, 2000)

The above is one of many quotations that have been gathered to support the understanding that girls, and indeed many boys, develop a negative view of the physical sciences because these are often presented as impersonal and irrelevant.

Science lessons all too often fail to tell a story that bears any relevance to personal lives, particularly girls' personal lives. Science is often portrayed as objective and dispassionate. As one of the pupils in Osborne and Collins (2000) put it:

A lot of the stuff is irrelevant, you're just going to go away from school and you're never going to think about it again. (Tamsin)

It seems that some of the materials used in the classroom can be positive and encouraging for boys,

but a hindrance to girls and their learning. As Mulemwa (1997) concluded:

Educational materials tend to build more on the experiences of boys and totally ignore those of girls.

Such studies have found that the authors of the materials were often male and were therefore drawing on their own gender's experience. The language and pictures often omitted women or portrayed them in passive rather than active roles.

It is not only women who are under-represented in science textbooks: black scientists feature very little in UK science textbooks or materials (Reiss, 1993). The portrayal of science and engineering therefore creates an image that selectively models white people. For example, while the UK Department for Trade and Industry's *Actions For Engineering* material represents females well, it neglects to include any representation of minority ethnic people (Rasekoala, 1997).

Science and society – a narrative approach

Some research suggests that school physics in particular can be criticised as being detached from daily life and removed from a wider social context (Vlaeminke *et al.*, 1997). In the Netherlands, an innovative physics curriculum made particular efforts to deliver 'girl-friendlier' topics. This apparently had a positive effect on girls' attitudes and their enjoyment of the units. These girl-friendlier topics connected with the environment, social issues and the world around us. Research into the relationship between girls and science in Africa suggests that women in developing countries have a strong affinity with their environment and that environmental education is therefore attractive to the female learner. The conclusion of Australian research that encouraged pupils to write in different voices was that approaches were more successful if girls' feelings could be expressed as part of learning.

It is not solely the female learner who verbalises the gap between personal experience and school science. The Connections Across Cultures project interviewed more than 200 pupils in particular target populations: females, American Indians, African-Americans and Latinos (Behm, 2001). A conclusion drawn from the in-depth interviews was that pupils wanted to bring to science what was meaningful in

their own lives; they needed to relate personally to classroom materials.

It appears that many pupils find that there is a gulf between their personal experience and their learning experience in the science classroom, and would appreciate greater integration of home life, personal experience and learning in science. Many pupils are also critical of what they perceive as the lack of relevance of much of school science (Osborne and Collins, 2000; Reiss, 2000). Some recent work suggests that thinking carefully about the contexts in which engineering tasks are presented can make them far more attractive to girls. Interactive GCSE textile projects (a temperature-controlled pet blanket, a railway safety jacket, etc.) at Belvedere School in Shrewsbury have:

managed to encourage more girls to stick with electronics ... [and] has also inspired a few more boys to use textiles in their final projects.
(Brooks, 2003)

It has been suggested that personal experience and story-telling strategies are helpful in providing better access for those learning science in their non-mother tongues. Many pupils, whether or not they are learning in their first language, have problems with the use of English language in science, including grammatical structure (e.g. the passive voice still sometimes favoured in science discourse), the specialised vocabulary (including polysyllabic words, such as photosynthesis, at even quite a young age) and the specialised use of everyday words (e.g. energy, work, force and power in physics) (Simich-Dudgeon and Egbert, 2000/2001).

Activities that require pupils to tell their own stories not only integrate their experiences with their learning but also help them to avoid or overcome language difficulties sometimes found in classroom materials:

It's important that students get to tell their story, some students actually don't 'get it' until they've told their part.

(Simich-Dudgeon and Egbert, 2000/2001)

Using analogies or story-telling strategies also engages those learners who do not tend to stack up information methodically but prefer to be presented with the big concept, an overview or a context first.

Story-telling strategies help to weave personal experiences into the science curriculum. However, it is not only personal experience that pupils bring to the classroom: it is also their preferred learning styles.

The way that a pupil prefers to process information can include or exclude them from learning what is being taught.

Access for all learning styles

Most pupils can utilise a range of learning styles but may have strengths or weaknesses in particular styles. For example:

- **Kinaesthetic learners** express their feelings physically and learn most effectively through activity. It has been suggested that more than 30 per cent of pupils may prefer kinaesthetic learning. According to Reiff (1992), many of the pupils who are underachieving at school are kinaesthetic learners; consistent instruction that is not accommodating their requirements can mean that they lose confidence, fall behind and may experience repeated failure.
- **Visual learners** think in pictures and have pictorial imaginations. They have a tendency to recall concepts that are presented pictorially.
- **Auditory learners** learn through hearing and speaking. In a silent test environment or a revision context these pupils may find that they can accommodate their preference for sound by playing classical music.

Dunn and Dunn have carried out extensive analysis of their 1978 model of learning-style preferences (Dunn and Dunn, 1978) and have reviewed a large number of subsequent experimental studies (Reiff, 1997). Their analysis indicates that pupils' academic achievement is significantly raised by matching teaching approaches to preferred learning styles.

'The Pilots Project' (Thomson *et al.*, 1999/2001) is an example of a research project that took account of learning styles. Pupils were given an inventory in order that they, alongside teachers, could work out what particular learning style they preferred. It was concluded that most pupils were tactile and kinaesthetic learners with little auditory strength. These pupils responded well to using their hands in visual memory exercises, to pacing while memorising and to using floor games.

This research suggested that most learners who are underachievers are not auditory processors, even though information in the classroom is often verbal. Many pupils valued being able to move periodically in the lessons. The teachers considered the pupils' learning styles to the extent that they restructured the

timetable so that preferences for learning at different times of the day were also accommodated. The success of this project was judged on the results of a test that the pupils had sat before but repeatedly failed. Even though the pupils were forced to sit an exam in an environment that might not have accommodated their learning strengths, the results are impressive. After embracing their learning styles, 75 per cent passed.

Helping pupils to understand their learning requirements, strengths and weaknesses and to become independent learners can help them combat some of the issues surrounding presentation of material and curriculum content in ways that may not suit every individual learner. It would seem possible to enhance the learning of every individual, regardless of ethnicity, gender or social class, by diagnosing their specific learning preference and employing multi-sensory strategies in the classroom. Such an approach avoids the danger of gender-specific or even racially-specific initiatives giving the impression that science is inherently a white, masculine subject that has to be watered down to accommodate women and ethnic minorities.

The practical should be a positive

Practical work in science is popular with most pupils and particularly assists the kinaesthetic learner. However, if the learning climate in practical work is based on competition and allows boys to dominate, even the most girl-appropriate content will not encourage girls to participate. The way in which hands-on activities are presented is crucial to pupils' appreciation of the subject. Female learners prefer to collaborate with others and are more likely to try to accommodate all other perspectives, whereas males are more likely to come to their own particular conclusion and then persuade others in the group to their point of view.

A girl-appropriate science approach to practicals could encourage girls to participate actively. Early examples of how teachers can include or exclude girls from science practical work were presented in the Girls into Science and Technology research (Kelly, 1987). The researchers observed classic gender responses among 11–14 year-olds to handling equipment – such as the bravado of boys playing tug-of-war with magnets and using ray-boxes to mime an interrogation. These examples were contrasted with

the female response. In one class, following the warning from a teacher that the experiment was dangerous, the boys responded by calling out 'Great' whereas the girls were evidently scared. The girls then approached the experiment with timidity and in some cases chose to become the onlookers.

Group-work approaches

Strategies that have been suggested for assisting girls in their approaches to hands-on activities include setting up apprenticeship projects, clubs and assertion-and-leadership training. Making the groups single sex is another option that has long been discussed for both science education and sex education. However, the results of the research on the benefits of single-sex classes or schools for girls are still inconclusive though there is some evidence that self-esteem can be higher in all-girl groups, that girls in single-sex groupings are less likely to see themselves in traditional roles, and that girls at single-sex schools are more likely to study mathematics and the physical sciences once they have the choice (Vlaeminke *et al.*, 1997; Arnot *et al.*, 1998).

Telling pupils to work together and leaving them to it will not produce collaboration. However, in one research project (Matthews and Sweeney, 1997), when pupils were required to learn about how they collaborate in groups, this produced some positive responses for both girls and boys and for pupils from a range of ethnicities. Written reports from pupils began to show an understanding of the need to change the way that they spoke to each other and to collaborate to make decisions. The pupils also began to acknowledge the skills they required in order to work alongside others. They began to monitor themselves and the way that they negotiated with other learners. Some of their responses were encouraging:

It has made me confident approaching others when I want to say something to them.
(female Bengali)

It gave me some new skills for managing in a group of people with different abilities.
(male Bengali)

It was particularly noteworthy that teachers who did not know the research was happening commented that the pupils were working more collaboratively. The research also suggests that collaborative learning can affect the inherent attitudes that science is impersonal and objective:

Group work has changed my view of science, it has made it appear more socially relevant, less distant and not only about knowledge but imagination as well. (female, West Indian)

Group work makes me feel more interested in science and makes it easier.
(female, white, post-16)

Overall, 90 per cent of the post-16 pupils said that group work and collaboration exercises made science more interesting while 55 per cent of key stage 3 pupils (11–14 year-olds) gave positive responses.

Pedagogy

It has been argued that the way teachers communicate with girls in the classroom can hinder learning. Kelly (1987) published an analysis of 81 studies that produced some quantifiable data on teacher–pupil interaction with respect to gender. She concluded that:

It is now beyond dispute that girls receive less of the teacher's attention in class and that this is true across a wide range of different conditions.

This may still be the case (Clair, 1995; Reiss, 2000). One survey of a high school geometry class revealed that girls received 30 per cent of encouraging remarks but 84 per cent of discouraging remarks (Clair, 1995). A range of research has concluded that male behaviour robs girls of teacher time in many classrooms.

The frequent decline in achievement of African-Caribbean pupils through the course of their schooling has often been attributed by parents to teachers' low expectations. Racism and racial stereotyping are often seen by parents to be casting shadows over the achievement of their children (Rasekoala, 1997). There is strong evidence of racial stereotyping in many schools, with black youngsters being over-represented in the take up of the various vocational courses. Black parents complain of children being encouraged into low-status, low-skill careers. Some are so concerned that they send their children to other countries to be educated.

Assessment

It is no longer the case that girls are less likely than boys to be entered for higher tier examination papers; the reverse, if anything, is sometimes the case. However, different forms of assessment seem to reflect a particular gender bias. There is a substantial

body of research showing that boys perform better than girls at objective (multiple-choice) tests (e.g. Bolger and Kellaghan, 1990). On the other hand, extended written accounts (notably essays) allow (even require) pupils to apply the information, to put it into a context (Kelly, 1987) and to generate narrative, which favours traditionally female-like ways of writing.

Using role models

Role modelling and mentoring have been explored as routes to help engage girls with science. For example, in one project positive role models were brought into schools: women were recruited who were outgoing and initiating. This project was particularly interested in de-stereotyping the objective and value-free image of science. Pupils' evaluations of the visits were positive, with girls particularly saying that they enjoyed seeing women in some of their jobs (Kelly, 1987). On the other hand, a somewhat similar project, which brought female scientists into regular contact with pupils in an elementary classroom in the USA, failed. Despite the efforts of the scientists to encourage the pupils to question their existing images of scientists, the pupils held on to stereotypical images. It turned out this was because the pupils did not perceive the visitors as scientists, seeing them as teachers instead (Buck *et al.*, 2002).

There is some, largely anecdotal, data indicating that role models can make a difference in breaking down the common perception that scientists are white. At the same time, in-depth ethnographic interviews with successful black people suggest that, while black role models can be important, many other factors are involved (MacDonald, 2001). Provided schools avoid making culturally specific assumptions – for example about what constitutes acceptable behaviour – black pupils can thrive in schools predominantly staffed by white staff, just as girls can thrive when taught by men and boys when taught by women (see Ofsted, 2002a, 2002b).

Of course, the most important female role model is the mother and research has been conducted that shows the positive effect of training mothers in the school subject in which their daughters are weakest. After six months, the improvement in the results of girls whose mothers were involved in the training was described as being 'spectacular' (Clair, 1995).

Conclusions

There is undoubtedly no single 'solution' to the 'problem' of underachievement by certain groups. For a start, the nature of the perceived problem shifts over time. Currently there are those who see the gender gap in terms of girls doing better in virtually all school subjects – including science – than boys, while there are those who see the gender gap in terms of fewer young women choosing to take certain subjects post-16 and in eventually having lower salaries even when they do jobs that require the same abilities. And then, if there had been a single solution one imagines that it would by now have been found.

Perhaps unsurprisingly, research in schools in which minority ethnic pupils do well shows that a raft of factors are important, including school leadership and management, the positive relationships

enjoyed with pupils and an enriched curriculum. In addition, a science education that took seriously the search for social justice as one of its aims would be a richer education and an education more likely to satisfy pupils interested in fairness and human concerns (Reiss, 2003).

What can be concluded is that apparent underachievement in science and technology by particular groups is strongly connected to the ways that society views the members of these groups. In turn, such views can become internalised so that people see themselves as others see them. This can be undone but requires conscious effort. It is simply not enough for schools to be isolated islands of good practice; they need to help learners to reflect critically on the world inside and outside school, and equip them with the necessary tools to deal with this world.

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