Count Me In! Gender and Minority Ethnic Attainment in School Science

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Brief description of article

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?

Abstract

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

Key words

Gender, minority ethnic, attainment, achievement

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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 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'. Secondly, 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 in 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 when 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 amount of undesired calling out and movement around the class from different categories of pupils. This is perceived (with more than a certain logic) as unfair by some pupils. A further 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 at it, such an expectation (from a powerful being like a teacher) shapes and may well become the reality.

There is, though, a danger in simply trying to treat each pupil as an individual and that is that 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 (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 correlates of differences in educational outcome, we find that more research is done on gender – and far more attention paid in the popular media to it – 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' (*sensu* politically less problematic) than by ethnicity or social class. Even less has been researched about science education and social class than about science education and ethnicity. For this reason we focus on gender and ethnicity, 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 than boys to chose biology and for boys to be more likely than girls to chose 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 do young men.

At every subsequent stage of science academia and the scientific industries, women become progressively under-represented so that, to cite the most extreme case, currently over 99% 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% of LEAs bidding for Ethnic Minority Achievement Grants (EMAGs) do not record GCSE attainment by ethnic origin. Another difficulty is the terminology used. Although 'Black' is still used by many as a label for themselves, may 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 essentialist 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 [pre-KS1] 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 eleven and sixteen.

Science can tell a story but 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, Yr. 10)

This research (Hatchell, 1998) suggests that the female contribution to science may well go largely ignored. Having collected data using open-ended questionnaires, participatory observation in classrooms and in-depth interviews, it was concluded that "most students suggested that scientists were mostly male and were unable to identify any female scientists from the past or present" (Hatchell, 1998).

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 towards 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 in Osborne and Collins, 2000)

It seems that some of the materials that are 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 gendered experience. The language and pictures often omitted women or portrayed them in passive rather than active roles.

Nor is it only women who are misrepresented in science text books. Black scientists feature very little in UK science text books or materials (Reiss, 1993). The portrayal of science and engineering therefore creates an image that selectively models white people. For example, while The DTI *Actions For Engineering* material represents females well, it neglects to include any representation of ethnic minority people (Rasekoala, 1997).

Science and society – a narrative to be explored

Some research suggests that school physics in particular can be criticised as being detached from daily life and removed from a social, wider 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, the world around us and social issues. Research looking at the relationship between girls and science in Africa makes the suggestion 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 students 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 verbalizes the gap between personal experience and school science. The *Connections Across Cultures* project interviewed more than 200 students of particular target populations – Females, American Indians, African Americans and Latinos (Behm, 2001). A conclusion drawn from the in-depth interviews undertaken was that students wanted to bring to science what was meaningful in their own lives. There was a need for students to relate personally to classroom material.

It appears that many students find that there is a gulf between their personal experience and their learning experience in the science classroom. There is a suggestion that greater integration of home life, personal experience and learning in science would be appreciated by many school students. 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)

Personal experience and story telling strategies have been suggested as being able to assist 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, find problems with the 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 students 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 students bring to the classroom – it is also their preferred learning styles. The way that a student processes information using specific modalities has the potential to include or exclude a student in their learning.

Access for all learning styles

Most students learn with all modalities but may have certain strengths or weaknesses in certain modalities.

- Kinesthetic learners express their feelings physically and these students learn most effectively through activity. It has been suggested that more than 30% of students may have kinesthetic learning preference. According to Reiff (1992), most of the students who are underachieving at school are often kinesthetic learners, and 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 students may find that they can accommodate their preference for sound by playing classical music.

Dunn and Dunn have carried out some 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). This analysis indicates that a matching of teaching approaches to preferred learning styles significantly raises student academic achievement of students.

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

It is suggested from this research that most learners who are underachievers are not auditory processors even though information in the classroom is often verbal. Many students valued being able to move periodically in the lessons. The educators considered the students' learning styles to the extent that they re-structured 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 students had sat before but repeatedly failed. Even though the students were forced to sit an exam in an environment that might not have accommodated their learning strengths, the results are impressive. 75% after embracing their learning styles passed.

Helping students to understand their learning requirements, strengths and weaknesses and providing ways to enable them become independent learners can help students combat some of the issues that surround presentation of material and curriculum content which 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 appropriately diagnosing their specific learning preference and employing multisensory 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 kinesthetic 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 help include girls in active participation. 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 to 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 also another option that has been long-discussed in 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-sexed groupings are less likely to see themselves in traditional roles, and that girls at single-sexed 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, 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 (Matthews and Sweeney, 1997). 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 students were working more collaboratively. The research by Matthews and Sweeney (1997) 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% of the post-16 pupils said that group work and collaboration exercises made science more interesting while 55% of Key Stage 3 pupils gave positive responses.

Pedagogy

It has been argued that the way that teachers communicate with girls in the classroom can be a hindrance to them. Kelly (1987) published a meta 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% of encouraging remarks but 84% of discouraging remarks (Clair, 1995). A range of research has concluded that male behaviour robs girls of their 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 skilled 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 which shows 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) students 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 modeling and mentoring have been explored as routes to help engage girls into 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. Student 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 onto stereotypical images. It turned out this was because the pupils rejected the visitors as scientists, seeing them as teachers instead (Buck *et al.,* 2002).

There is some, largely anecdotal, data 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, there are many other factors 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 under-attainment 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 on 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 students interested in fairness and human concerns (Reiss, 2003).

What can be concluded is that apparent under-achievement 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 pupils and students critically reflect on the world inside and outside of school, and then equip students with the necessary tools to deal with this world.

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References

Arnot, M., Gray, J., James, M., Rudduck, J. with Duveen, G. (1998) *Ofsted Reviews of Research: Recent Research on Gender and Educational Performance*, The Stationery Office, London.

Behm, C. (2001) Big picture science, in *Celebrating Cultural Diversity: An NSTA Press Journals Collection*, NSTA Press, Arlington, Virginia, pp. 34-37.

Bolger, N. and Kellaghan, T. (1990) Method of measurement and gender differences in scholastic achievement, *Journal of Educational Measurement*, 27, 165-174.

Brooks, Y. (2003) Current obsession, *TES Teacher*, January 17, 6.

Buck, G. A., Leslie-Pelecky, D. and Kirby, S. K. (2002) Bringing female scientists into the elementary classroom: confronting the strength of elementary students' stereotypical images of scientists, *Journal of Elementary Science Education*, 14(2), 1-9.

Clair, R. (1995) *The Scientific Education of Girls: Education beyond Reproach*, Unesco, Paris.

Dunn, R. and Dunn, K. (1978) *Teaching Students through their Individual Learning Styles*, Reston.

Gillborn, D. and Mirza, H. S. (2000) *Educational Inequality: Mapping Race, Class and Gender – A synthesis of research evidence, HMI 232*, Office for Standards in Education, London.

Hatchell, H. (1998) Girls entry into higher secondary sciences, *Gender and Education,* 10, 375-386.

Hughes, G. (2000) Exploring the availability of student scientist identities within curriculum discourse, *Gender and Education*, 13, 275-290.

Kelly, A. (1987) *Science for Girls*, Open University Press, Milton Keynes.

MacDonald, J. (2001) *Portraits of Black Achievement: Composing Successful Careers*, Lifetime Careers, Trowbridge.

Matthews B. and Sweeney, J. (1997) Collaboration in the science classroom to tackle racism and sexism, *Multicultural Teaching*, 15(3), 33-36.

Mulemwa, J. (1997) *Scientific,Technical and Vocational Education of Girls in Africa,* Education Sector.

Ofsted (2002a) *Achievement of Black Caribbean Pupils: Three Successful Primary Schools, HMI 447*, Ofsted, London.

Ofsted (2002a) *Achievement of Black Caribbean Pupils: Good Practice in Secondary Schools, HMI 448*, Ofsted, London.

Osborne, J. and Collins, S. (2000) *Pupils' & Parents' Views of the School Science Curriculum: A study funded by the Wellcome Trust*, King's College London, London.

Peters, J., Lane, N., Rees, T. & Samuels, G. (2002) *SET Fair: A Report of Women in Science, Engineering, and Technology from The Baroness Greenfield CBE to the Secretary of State for Trade and Industry*, Department of Trade and Industry, London.

Rasekoala, E (1997) Ethnic minorities and achievements. The black hole in science ranks part 2: post-16 education, *Multicultural Teaching*, 16(1), 12-15.

Reiff, J. (1997) *Learning Styles*, National Education Association, Washington, DC.

Reiss, M. J. (1993) *Science Education for a Pluralist Society*, Open University Press, Milton Keynes.

Reiss, M. J. (2000) *Understanding Science Lessons: Five Years of Science Teaching*, Open University Press, Buckingham.

Reiss, M. J. (2003) Science education for social justice in C. Vincent (ed.) *Social Justice, Education and Identity*, RoutledgeFalmer, London, pp. 153-165.

Richardson, R. and Wood, A. (1999) *Inclusive Schools, Inclusive Society: Race and Identity on the Agenda*, Race on the Agenda in partnership with Association of London Government and Save the Children, Stoke-on-Trent, Trentham.

Simich-Dudgeon, C. and Egbert, J. (2000/2001) Science as a second language, in *Celebrating Cultural Diversity: An NSTA Press Journals Collection*, NSTA Press, Arlington, Virginia, pp. 68-72.

Thomson, B. S., Carnate, M. B., Frost, R. L., Maxwell, E. W. and Garcia-Barbosa, T. (1999/2001) Creating a culture for success, in *Celebrating Cultural Diversity: An NSTA Press Journals Collection*, NSTA Press, Arlington, Virginia, pp. 25-33.

Vlaeminke, M., McKeon, F. and Comber, C. with Harding, J. (1997) *Breaking the Mould: An Assessment of Successful Strategies for Attracting Girls into Science, Engineering and Technology*, Department of Trade and Industry, London.

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