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Opportunities from Physics

Interventions in a multi-ethnic school to increase post-16 participation

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Contents

1

Introduction

In recent years, the Institute has worked hard to understand the complex participation rates of students from black and minority ethnic (BME) groups. In 2006[1] and 2008[2], the Institute, in conjunction with the Royal Society of Chemistry (RSC), commissioned research into the level of participation of students from different ethnic groups in physics and chemistry, and the factors that influenced subject choice. This research found that students from certain Asian backgrounds were very well represented within higher education (HE) more generally but were significantly under-represented in physics, despite being qualified to take the subject. The research found that the main reasons for this were ignorance of what physics is and what career options were available to those that studied physics. The influence of family was also a strong factor in many cases.

The research made several recommendations for increasing BME participation in physics, including: a focus on increasing the enjoyment of young BME students in physics; illustrating the relevance of physics to everyday life; providing comprehensive careers information to young people and their families regarding the range of options available to physics graduates; and highlighting BME role models among those employed in physics-related careers.

[1] Elias P, Jones P and McWhinnie S 2006 *Representation of Ethnic Groups in Chemistry and Physics* London: Institute of Physics and Royal Society of Chemistry.

[2] Springate I, Harland J, Lord P and Wilkin A 2008 *Why choose physics and chemistry? The influences on physics and chemistry subject choices of BME students* London: The Institute of Physics and the Royal Society of Chemistry.

Summary of project

The Institute formed a partnership with a school in west London with a high proportion of students from BME groups to run a pilot project, with the aim of determining which science enhancement and enrichment activities would most stimulate these students' enjoyment of physics. The pilot was carried out with 70 students from Year 9, who were selected by the school as having achieved sufficiently high grades to proceed onto the triple-award GCSE science course and so were most likely to qualify to study A-level physics. Around half the group were male and half female and, in terms of their ethnic make-up, the majority of the group identified themselves as Indian or Pakistani, with smaller numbers as Black African or Black Caribbean, White, Arab, Somali and Bangladeshi. A significant proportion of the students (33%) stated they were eligible for free school meals (FSMs). Therefore, we worked with students from predominantly BME backgrounds, who already had high aspirations, engagement and attainment in science, but not necessarily in physics.

> "My family support me, they want me to go to university and A-levels, so I think I have the motivation to go to university.

The school had recently introduced a physics A-level course and was keen to recruit more students into physics, so was receptive to Institute support. The school was supported with the project interventions, which targeted both students and parents over a two-year period, and through engagement with the Stimulating Physics Network (SPN), which provided continuing professional development (CPD) for the teachers in the science department that were not directly involved in the project. This consisted of 10.5 hours of CPD for the non-specialist physics teachers and seven hours of CPD for technicians at the school. The head of science, a chemist, also attended an SPN summer school to enhance subject knowledge for non-specialist teachers of physics.

The student interventions used as part of the project were ones that are commonly employed in school science enrichment activities: "hands-on" demonstrations; lectures; out-of-school visits; and classroom resources. The parental intervention was a science careers awareness evening event, which was designed to ensure that parents and students were more aware of the various post-16 opportunities for students pursuing science-based qualifications.

An initial student survey was carried out before the intervention work began to determine their general interests, in order to tailor the interventions more appropriately and to provide baseline indicators of their attitudes to science generally and towards chemistry, biology, physics, maths and English specifically. Students were asked to rate statements on a Likert scale (strongly agree to strongly disagree) on issues around science in society, on their enjoyment of specific subjects and lessons at school, and their attitudes towards the status and pay of graduates of chemistry, physics and medicine; they were also asked about their career aspirations and their parents' views on careers. An initial parent survey was also carried out before the interventions to determine parental attitudes towards their child's education and career aspirations, baseline indicators of their attitudes towards the importance of science, and their attitudes towards chemistry, physics, biology, maths and English in particular.

Following the interventions, follow-up student and parent surveys were carried out to determine if attitudes towards science and physics had changed. Six student focus groups were also convened to gain a deeper understanding of the pupils' attitudes and how aspirations were being shaped and translated

into career intentions. 31 students (out of the 70 we worked with) took part in the focus groups, which were selected by ethnicity and gender (where numbers allowed).

Individual and group teacher interviews were also carried out at the end of the project, covering the teachers' sense of the impact of the interventions on students and parents, and of the CPD they had received.

Intervention design

The series of student interventions had two central aims. The first was to build awareness among the students of the wide variety of career paths that were accessible to an individual with a background in physics, emphasising the potential for highly respected and well paid work. The second aim was to demonstrate to students the relevance of physics to everyday life and to show it to be an interesting and engaging subject. Table 1 details the interventions used as part of this project.

Based on the survey responses around general interests and broad career aspirations, the themes of medicine, space and computer games/visual effects were chosen for the student interventions. Medicine or medical-related careers were professions that many of the students aspired to, computer games was a topic that many students identified as one of their top interests and space provided an ideal vehicle to introduce students to the relevance of physics to industry. In all activities, other than the in-lesson activity, the students were given the opportunity to meet either physics or engineering graduates.

The parental intervention was a "Careers from Science" parents' evening aimed at increasing awareness among parents of the highly respected and well paid careers open to someone with a background in physics. The evening event opened with a talk on making informed choices about A-level subjects. Parents and students then had the opportunity to speak to representatives with backgrounds in physics or engineering from a wide range of careers, both inside and outside of science, with emphasis on the transferable skills developed by studying physics.

Table 1: The interventions used as part of this project

Format	Theme(s)	Description
"Hands-on" demonstration	Physics in medicine	Students (in small groups) moved around eight activity stations led by physicists demonstrating applications of physics in medical settings. Students spent 15 minutes at each station.
Lecture	Medical physics	Students attended a one-hour lecture at the school delivered by a working medical physicist on imaging techniques and their use in medicine.
Out-of-school visit	Space industry	Students visited a satellite-engineering company for a tour of the site and a hands-on engineering workshop.
In lesson	Games design and visual effects	Careers in computer games and visual effects were highlighted as part of a lesson in which students carried out practical investigations into the forces in a car crash.
Careers evening	Careers from science	Both parents and students were invited to talk to eight graduates that had studied physics or engineering at university who now had careers both in and outside science.

4

Main findings

Student's enjoyment of the interventions

Following each intervention, we asked for immediate feedback and, during the focus groups, the students were asked to reflect on the interventions and to identify which were more memorable and why. While the lecture, at the time, was viewed positively, in the focus groups it was less memorable and viewed more negatively. In contrast, the visit to the satellite company at the time was viewed relatively negatively, but when asked to reflect on it, the students rated it the second most popular of the interventions. The Physics in Medicine activity was viewed the most positively both at the time and in the focus groups.

There were two main reasons that the Physics in Medicine activity and the off-site visit stood out when students were asked to reflect on them: they were interactive and they were seen as different from school physics.

> "The [hands-on intervention] was the most interactive and we got involved…It wasn't just like a lecture.

> "We saw lots of space shuttles and…stuff we hadn't seen before and we'd learnt about, so we got to see it first-hand.

> "When he came to give his speech it was more listening…and I didn't really learn anything because he was too fast. But I think the activity, you get to do it in your own pace and you're doing it yourself…you understand it because you're the one doing the experiment.

Students' attitudes to science and physics

The survey results showed that science was already viewed very positively by the students in Year 9 and, following the project interventions, even more so in Year 11. Table 2 shows baseline (Year 9) and post-intervention ratings (Year 11) for each of the three separate sciences and maths in school. Each statement was rated on a five-point Likert scale from "strongly agree" (5) to "strongly disagree" (1). Students continued to enjoy school science and, when answering subject-specific questions, physics showed the greatest absolute shift and relative increase when asked to rate "I enjoy lessons" and "My parents think it is important that I do well in it".

Similarly, table 3 compares student ratings for graduates in medicine, chemistry and physics. After the interventions (Year 11) physics

Table 2: Changes in attitudes to school subjects (average Likert ratings, n = 58)

	Chemistry			Physics			Biology			Maths		
	Year 9	Year 11	Change	Year 9	Year 11	Change	Year 9	Year 11	Change	Year 9	Year 11	Change
Enjoy lessons	3.70	3.93	+0.23	3.33	4.04	+0.71	3.88	4.12	+0.24	3.70	3.93	+0.23
Am good at it	3.70	3.95	+0.25	3.35	3.75	+0.40	3.63	4.12	+0.49	3.96	3.96	0.00
Parents think it's important I do well	3.82	3.95	+0.13	3.65	3.95	+0.30	3.95	4.00	+0.05	4.45	4.53	+0.08

Table 3: Changes in attitudes to graduates (average Likert ratings, n = 58)

	Chemistry graduates			Physics graduates			Medicine graduates		
	Year 9	Year 11	Change	Year 9	Year 11	Change	Year 9	Year 11	Change
Are well paid	3.81	3.84	+0.03	3.82	4.04	+0.22	4.26	4.30	+0.04
Do exciting things at work	3.68	3.79	+0.09	3.61	4.09	+0.48	3.60	4.16	+0.56
Hold positions of importance	3.77	3.81	+0.04	3.68	4.04	+0.36	4.28	4.32	+0.04
Are well respected	4.00	4.07	+0.07	4.00	4.09	+0.09	4.30	4.35	+0.05

graduates were viewed more favourably when compared with chemistry graduates on most of the measures. The biggest absolute jump for physics was for the statement that graduates "Do exciting things at work", although ratings for medicine saw a bigger jump.

In the focus groups, many of the Asian students talked about science being an "Asian thing" although some linked it with a desire to do medicine.

> "I have one, two, three, four doctors…I have an optician…I have two psychiatrists in my family. It's kind of traditional as an Asian family to do that kind of thing.

Overall, the attitudinal data suggested that, following our interventions, students viewed physics graduates more favourably than chemistry graduates, enjoyed physics lessons more in Year 11 than Year 9 and felt that their parents' appreciation of the importance of physics had increased over the period of the interventions. The highest overall change in attitude was that medical graduates "do exciting things at work" (table 3).

Student's educational aspirations and choices

In both surveys, students were asked questions about their likelihood of studying physics after their GCSEs. In the initial survey, they were asked to state how strongly they agreed or not with the statement "I want to study physics after GCSEs" and in the second survey a free-box for responses on intended A-level subjects was provided.

Detailed information for intended subject choice in Year 11 was available only for the 48 students who completed a free-response box on the post-intervention survey. Intended A-level subject choices by gender and ethnicity are shown in tables 2 and 3, respectively.

Unsurprisingly, boys were much more likely to say that they intended to take A-level physics than girls. 67% of boys (for whom we have data) were planning to take physics compared with 29% of girls (a statistically significant difference). All eight respondents who planned to take science subjects other than physics were female. Overall, students from Indian backgrounds were the most likely to choose physics (67% of those who supplied sufficient data, compared with 48% across the whole sample) and had a much smaller gender gap (9/13 or 69% of boys compared with 5/8 or 63% of girls).

When we looked at intentions to take A-level physics in more detail, we found a complex picture. Out of the original group of 70, only 45 students provided sufficient data for physics in both surveys. We found:

- Nine of the 19 students who had strongly agreed or agreed with the statement

"I want to study physics after GCSEs" in Year 9 now expressed intent on taking A-level physics.

- Eleven of the 19 students who responded that they neither agreed nor disagreed with the statement now expressed intent on taking A-level physics.
- Two of the seven that had disagreed or strongly disagreed with the statement now expressed intent on taking A-level physics.

Parents' aspirations

With this group of students, through the parents' surveys, we found that medicine appeared to hold particular significance as parents rated people who study medicine highest on all three of the survey measures: "Are well paid"; "Hold positions of importance"; and "Are well respected". Physics came second on "Are well paid" and third, behind chemistry, on "Hold positions of importance" and "Are well respected". When parents were asked to identify a job that they thought would provide what they felt was important for their child, many chose careers related to medicine (including dentistry and veterinary).

While parents were not explicitly acknowledged by the students as influential in their subject choice, there was a strong correlation in the Year 9 survey between the perceived parental benefit of a subject at A-level and a preference to study it post-16, but no correlation with enjoyment of a subject or being good at it.

The majority of parents that attended our careers evening found it both informative and enjoyable, with almost half describing it as inspiring.

The students also enjoyed the parents' evening:

> "[At the parents' evening] you got to know as well what your parents want you…I found the games designing one interesting and they said that was okay.

> "I think it helped them get a better idea of what we were actually learning, because I don't think my mum really knew too much about physics.

Teachers' attitudes towards the interventions

A short evaluation was also carried out with the teachers involved in the Institute's pilot to measure how successful they felt the programme had been in getting more students to progress to A-level physics and in improving students' and parents' attitudes towards the subject. The survey also assessed the impact of the SPN on the confidence and subject-specific knowledge of teachers delivering physics lessons at the school.

The teachers were overwhelmingly positive

Table 4: Intended subject choices at A-level by gender in Year 11

A-level combinations	Female	Male	Total
Sciences including physics	3	6	9
Mixed including physics	4	11	15
Sciences not including physics	8	0	8
Mixed not including physics	6	6	12
Non-sciences	3	1	4
Total	**24**	**24**	**48**

Table 5: Intended subject choices at A-level by ethnicity

A-level combinations	Indian	Pakistani	Black African	Other	Total
Sciences including physics	5	1	1	2	9
Mixed including physics	9	2	1	2	14
Sciences not including physics	1	2	0	5	8
Mixed not including physics	0	1	2	10	13
Non-sciences	0	1	2	1	4
Total	**15**	**7**	**6**	**20**	**48**

about the interventions and thought that the parents' evening had been a particular success. They felt that the parents of the student cohort had significant influence over the students' career aspirations and for this reason getting parents "on-side" was essential. The interventions also helped the teachers with a focus point for discussions about career options.

The teaching staff were overwhelmingly positive about the support provided via the SPN, with many noting an increase in confidence to teach the subject, particularly among non-specialist teachers. However, there was a strong sentiment that things would not change overnight and sustained contact with the SPN would be necessary to consolidate the gains in confidence and subject-specific knowledge that had been made by the science department's teachers.

> "Because you tend to promote jobs and job opportunities but you do it in a sort of ad-hoc way, whereas being involved in the project, there were key moments…where you would have discussions about what jobs you could get from it and what the next steps were. So that's been the best outcome.

5

Discussion

This pilot project sought to investigate which school-based interventions might influence participation in A-level physics among a cohort of students who were predominantly from a BME background. The project worked with a school that offered triple-science GCSE awards taught by specialist physics teachers and worked with young students, predominantly from South Asian backgrounds, who already had high aspirations, engagement and prior attainment in science. Wider research has shown that while some BME groups are more likely to be oriented towards science already, some may need "turning on" to science more generally and others will need work to raise their attainment in science to match their aspirations (Wong 2012)[3].

The project took place over a two-year period and we invested time at the beginning of the project to build and nurture relationships with the school. Throughout the project we were responsive to teachers' needs and understood the constraints within which the teachers worked. There was also a high level of enthusiasm exhibited by members of the school's science department whose agenda, in terms of increasing aspiration and attainment in physics, was in line with that of the Institute.

While there was a lot of enthusiasm for science subjects, many students were not aware of the diversity of jobs within the science or physics workforce, outside of those relating to medicine. Demonstrating the relevance of physics to everyday lives and providing information on the variety of doors opened up by studying physics was crucial in increasing the aspirations for physics among these BME students. The interventions also allowed teachers to embed careers advice into the lessons and have discussions about careers from physics as a result of the activities.

We found that feedback from students immediately after an activity did not necessarily correspond to how memorable the activity was in the longer term. At the time of the activities, the off-site visit was not instantly popular although it was, together with the hands-on activity, the most memorable in the longer term as it was seen as different from "normal lessons". We also found that many of the students became more positive about careers in medicine, as well as physics, and it is unclear if this was an unintended consequence of the focus of some of the interventions on medical physics or other factors.

Targeting both students and parents provided an effective method of promoting the value of studying physics. Research has shown that teachers are ubiquitously identified as key influencers over student subject choice (Lorenz 2012[4], Mendick 2008[5], and Smart and Rahman 2008[6]) and our previous research[1] indicated that among certain ethnic minority groups, such as the South Asian groups on which this project focused, parents are also key influencers. Engaging parents by demonstrating the applicability of physics in different career settings was particularly important, as many of them had high aspirations for their children to have a career in science, particularly medicine.

Data from our surveys suggested that there was likely to be an increase in the numbers who intended to take physics post-16. In our group of 70 in Year 9, 19 out of 45 "strongly agreed or agreed" that they wanted to take physics post-16. By Year 11, 22 out of 45 expressed an intent to take A-level physics the following year. Of these 22, just under half (10) were from the 19 who had originally "strongly agreed or agreed" in Year 9 and two were from the group who had originally "strongly disagreed". This clearly shows the fluidity of subject choice as young people progress through school.

Of the 24 students that progressed to AS physics at the school in the following year, 21 were from our target group. [Three additional

[3] Wong B 2012 *Science aspirations: Investigating the views of 11-14 year old minority ethnic pupils* Unpublished PhD thesis. King's College, University of London.

[4] Lorenz M 2012 *Gravitating towards physics: How will higher fees affect the choices of prospective physics students* London: Institute of Physics.

[5] Mendick H 2008 Subtracting difference: troubling transitions from GCSEs to AS Level Mathematics, *British Educational Research Journal* **34** 711–732.

[6] Smart S and Rahman J 2008 *Bangladeshi girls choosing science, technology, engineering and maths* London; CfBT Education Trust.

male students that had been accepted onto AS physics were from non-triple science groups.] Comparisons to the historical uptake of A-level physics at the school were limited by the fact that the school had only recently introduced a sixth form and data for the number of students that joined the school from other schools were not available for previous years. However, the 24 students starting AS physics represented an increase of at least 21% when compared with the best previous year for recruitment.

6

Lessons learned

- Investing time at the beginning of the project to build and to nurture relationships with the school, and being responsive to teachers' needs, are crucial for a successful intervention.
- Understanding the prior engagement and aspirations that the different BME groups have in science is important to ensure that activities and interventions are targeted appropriately. A key element of the success of the pilot was the focus on designing interventions that were relevant to the students' specific interests and aspirations.
- Different activities were memorable (or not) for different reasons, but the most popular in the longer term were those that were "outside" normal lessons.
- Engaging parents and ensuring they were aware of the various well paid and high-profile careers available from physics and science worked extremely well.
- Embedding careers advice into lessons as a result of the interventions provided a stimulus to allow teachers to have key discussions about different jobs and the steps to take to get them.
- There is real fluidity of subject choice as the young people progress through school. Some of those who had indicated they were most likely to take physics post-16 subsequently did not and some who had indicated they were extremely unlikely to take it in actual fact did.

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