A study of UK secondary school students' perceptions of science and engineering

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Introduction

Over recent years in the UK the recruitment of people with the necessary skills and abilities in Science Engineering and Technology (SET) has significantly reduced. Even though the UK has a large and increasing number of students studying in Further and Higher Education (FHE), there is a decrease in those studying specifically for mathematics, physics and chemistry. The growing numbers of students are opting for studies in Law, the Biological and Medical Sciences, and Business Studies (HESA, 2005). A strengthening demand for physical sciences and highly numerate graduates has resulted in a national skills shortage. With similar trends throughout Europe it is of critical importance that educational researchers, from the UK and affected countries within Europe, with interests in SET ascertain why young people are not choosing to study SET related subjects beyond compulsory education. While a substantial range of data exists that has focused on this and similar themes, studies which aim to gain a better understanding of students' perceptions and views of the theme are relatively few. Currently there is a welcome trend in the UK which places significant importance on researching school students' views and perceptions in an attempt to aid development of a richer understanding. It is that research context which framed this current study.

Current SET contexts

A number of reviewers (Roberts, 2002, Rasekoala, 2001) have suggested that SET related subjects suffer from a worrying range of problems which need to be addressed if the supply of people with high quality science and engineering skills is to improve in the UK——a failure of the National Curriculum (NC) to facilitate practical/investigation sessions, a lack of positive role models in the fields of science and engineering, lack of effective careers advice that affect school students' aspiring to study SET after compulsory education, and girls' apparent disinterest in school-based science and technology to name a few. The following existing literature highlights these issues.

Central to inspiring and enthusing school students is high quality teaching within schools which operate to high standards. Although the current government perceives standards in UK schools to have risen over the last decade (DfES, 1997) a concerning factor is that fewer school students are choosing to study mathematics and physical sciences at A-level (pre-university entrance examinations in which students follow a two-year course between the ages of 16-18) even though A-level entrants have increased by more than 6% over the last ten years. The largest decrease in A-level entrants has been in Physics. Between 1991 and 1999 pupils taking A-level Physics in England fell by 21%. In the same period numbers of students taking mathematics and chemistry fell by 9% and 3% respectively (Roberts, 2002). This would clearly have an impact on the numbers of quality teachers coming through training in SET subjects.

An international comparative study of the Relevance of Science Education (ROSE), conducted by the University of Oslo, was developed to enable informed discussions about how to enhance school students' interest in science and technology and how to improve school science curricula and concentrated on school students' views. Reviewing

questionnaire data from twenty countries Professor Svein Sjoberg, from the ROSE project (2004) states that only a small number of students from industrialised societies have aspirations to become scientists or technologists with girls showing particularly low interest. This highlights a stark contrast with school students, of both genders, from developing countries who indicate that they value careers in science and technology highly. The ROSE project also found that while both boys and girls (less so for girls) perceived school science to be interesting and a subject that should be learned in school their dislike of science in comparison to other subjects was strong. These results are consistent with other studies from the UK.

Jenkins and Pell (2006) report findings from the ROSE project from the perspective of students in England . These are largely concurrent with those of other school students from industrialised nations globally. Even though participating students hold positive views of SET and society they are not 'reflected in their opinions about their school science education' (executive summary). Most boys but, in particular, girls prefer other subjects to science.

In a study of students' and parents' views of the UK school science curriculum Osborne and Collins (2000) state that while school students in the UK consider science to be an important subject that message is not clearly communicated to all students through school science. A point emphasised further by the Planet Science online study which reported that even though most respondent students perceive science to be 'useful' almost half (42%) believe that their GCSE science lessons don't evoke their curiosity and enthusiasm for pursuing greater knowledge about the world (Planet Science, et al, 2003).

A study of values and beliefs in relation to SET amongst 11 - 21 year olds in the UK, conducted by Nestle, (2004) shows that while most respondents are positive towards SET and feel that it is important many state that they would not consider a SET related occupation.

A number of reviewers have highlighted the content laden nature of the UK National Curriculum (NC) and its consequent failure to facilitate practical work in science classrooms (Osborne & Collins, 2000; Roberts, 2002). The NC is seen by many as rigid and inflexible leaving teachers with little opportunity to design and utilise innovative practical work. Although practical work is an integral part of the NC, and at Key Stage 4 contributes 20% of the General Certificate in Secondary Education (GCSE) grade, it can very often be relegated to work done just for assessment. While most science teachers accepted the NC in principle many have complained that it restricts the range of laboratory work undertaken and diminishes students' enjoyment of science (Jenkins, 2004). As practical work is more involved in terms of preparation and delivery teachers may avoid full class practicals in favour of brief demonstrations. However, this does not need to be the case. Subject content may be delivered through practical investigation and problem solving that is motivating and enthusing for students.

A lack of science and engineering role models has been cited by authors in the field as a potential problem particularly when in reference to making classroom science relevant to pupils everyday life experiences (Roberts, 2002, Rasekoala, 2001). The Royal Society offers a Partnership Grants Scheme that funds school teachers to work in collaboration with SET professionals through classroom project work. During research to produce a good practice guide for role models The Royal Society (2004) found that from 157 young people who had engaged in activity with a SET role model 41% said that prior to their experiences they were

not intending to study in the fields of SET but that they would now realistically consider it. Moreover, of 1000 scientists who responded to a Royal Society web survey about what influenced their career choice 29% indicated their parents had a strong influence with three quarters of those parents being SET professionals themselves. Rasekoala (2001) argues that black and minority ethnic students are significantly disadvantaged by a distinct lack of relevant role models in SET and that more collaboration between employers and schools in an attempt to encourage students from minority ethnic backgrounds to consider SET careers and study.

These studies raise many important questions which need in-depth consideration and, indeed, clear answers if serious attempts are to be made to develop approaches and/or interventions that will encourage more young people to choose to study SET related subjects post-compulsory education. For example, questions which identify influences on career choice and particular ages when students begin to think realistically about further study and careers. Their understanding of classroom science and how, if it at all, they relate this to professional careers? Answers to these and other key questions would provide substantial insight into how we might approach potential solutions.

Methodology

Our research aimed to elicit secondary school students' perceptions and views of science and engineering—both classroom science (including Design & Technology) and professional fields of science and engineering. Given the existing contexts of similar studies our immediate aim was to gain a better understanding of why limited numbers of young people are choosing to study SET related subjects beyond compulsory education.

A pilot questionnaire was developed and trialed in 4 schools with 120 pupils (this data is not included in this paper). Minor amendments were made to the questionnaire after receiving feedback from the trial schools. The questionnaire was then distributed to 50 schools across England who were selected to provide a sociocultural range of students. A total of 23 schools responded to the questionnaire providing data from 542 pupils. Data were analysed through the 'Excel' computer program with an additional 10 focus group interviews conducted in four schools with 150 pupils between the ages of 12 - 14 years. Data from focus groups were analysed through qualitative inductive methods based on open coding (Cohen and Manion, 1994). Text units were arranged from transcripts and notes from the focus group interviews. Emerging codes were then organised into themes based on converging responses from pupils which lead to the identification of common patterns.

Questionnaire data

Section one of the questionnaire invited students to indicate their preferred science subject in school and also asked them if they knew a practising scientist or engineer.

Table 1 Students' responses (by %) showing their preferred science, favourite part of science lessons and personal knowledge of a practising scientist or engineer

	Biology	Chemistry	Physics
1. My favourite science subject is	43	38	19
2. My least favourite science subject is	29	22	49
	Practical	Teacher talk	Writing
3. My favourite part of science lessons is	83	10	7

	Fam mem	Fam friend	None
4. I personally know a scientist who is	20	35	45

These results are resonant with existing studies of a similar focus. Physics is clearly the least popular subject of all three school sciences, while practical sessions are notably more favoured by students for classroom-based activity. Osborne and Collins (2000) show that students find practical sessions stimulating and more meaningful largely because practical sessions offer them more autonomy and control over their own learning. Almost half of the students report that they do not know a scientist personally, either as a family member or friend.

Table two shows students responses to statements from the second part of the questionnaire which attempted to gain data that would provide a realistic insight into how students view school science.

Table 2 Students' responses (by %) which focus on classroom science

	SA	A	DK	D	SD
5. I enjoy learning about science in school	16	53	18	11	2
6. I enjoy learning about science outside of school	6	22	22	33	17
7. I find science difficult to understand in school	3	17	24	41	15
8. My science teachers make science interesting	18	42	25	11	4
9. My teachers tell me about things that happening in science now	18	47	21	11	3
10. My teachers explain about careers in science	24	4	26	37	9

Results from table two again show resonance with other studies. Students register their enjoyment of learning science in school (69%) but are clear that that is where their interest

halts with half (50%) stating that they do not enjoy learning about science away from school. The large majority of students do not find science difficult to understand (56%) and believe that, overall, their teachers make science interesting (60%). While most students agree that teachers explain about contemporary issues in science (65%), almost half state that teachers do not explain about related careers (46%). The work done through the ROSE project and by Osborne and Collins (2000) also shows that school students tend to enjoy classroom science and are positive about their teachers. However, these studies also identify that these perceptions are not reflected in students views of science as a career or further study option.

Table three shows students' responses in relation to statements concerning scientific careers and science and society.

Table 3 Students' responses (by %) which focus on scientific careers and science and society

	SA	A	DK	A	SA
11. I would like to study science at A-level	18	21	32	14	15
12. I would like to study science at university	12	16	41	16	15
13. I am considering a science related career	17	13	38	19	13
14. I think science is important to the economic development of the UK	19	51	22	5	3
15. I think that science has a positive public image	8	38	41	11	2
16. I think science offers a wide range of careers	18	50	24	6	2
17. I think that scientists are generally well paid	10	38	44	6	2
18. I think there are more male scientists than female scientists	5	19	55	17	4
19. I think most scientists are above the age of forty	4	10	49	30	7

A relatively large number of students (39%) state they would like to study science at A-level. However, fewer (28%) stated they would like to go on to further or higher education study in science with a relatively high number (31%) stating they would not consider studying science beyond the age of eighteen. Perhaps, not surprisingly, the largest responses to these statements (11 and 12) are given as 'Don't Know'. During focus group interviews a great many pupils indicated that they have yet to decide whether or not to study science beyond compulsory education and were undecided about career choices. Most students (70%), reassuringly, believe that science is important to the economic development of the UK. However, their lack of enthusiasm for opting to take a scientific based career seems to indicate that either they have little understanding of the magnitude of the current skills deficit or little interest in the problem—a mixture of both would seem likely.

It is, perhaps, not entirely surprising that, with the exception of statement 16, the remainder of the results in the section (15, 17, 18 and 19) are dominated by 'Don't Know' responses. Given the large majority of responses to statement 4 were that students did not know a scientist personally and that they suggest, through statement 10 that their teachers do not engage in discussion about scientific careers, it would be unreasonable for students to make an informed response to these statements. Moreover, it appears to evidence a lack of knowledge and understanding of issues related to SET careers. Although, they do seem to agree that science-based careers are wide ranging.

Focus group interviews

Focus group interviews were conducted with groups of pupils ranging between 10 and 20 in number. The majority of students indicate that biology is preferred to physics or chemistry as

it is less complex. They note, specifically, that the latter two subjects require learning difficult equations and laws that biology does not require. Also, they feel that biology is more relevant—it is more tangible to them in as much as they recognise elements of biology such as animals and plant life through everyday experiences. Whereas, elements of physics and chemistry are less obvious to them throughout their daily experiences:

> Its too hard [Physics] there are too many laws and stuff. It *doesn't really matter anyway I will never need that type of* stuff when I start work. You only need to know it if you want to do physics as a job (student).

> Biology is easier to understand because you can relate to it *more…because its all around you.* Your own body, animals *and things…its more meaningful because it seems closer to* you everyday (student).

The large majority of students also state that there are less practical/investigation sessions during physics lessons. They suggest that they prefer to be engaged in practical sessions rather than copying text or observing demonstrations:

> Its better to do practical lessons they're more fun and help you to find out better about things for yourself. I don't like copying notes or watching the teacher do experiments (student).

Some students suggest that physics would benefit from 'sexing up' in an attempt to make it more appealing. They stated that teachers, where possible, should not only engage pupils through practical/investigation sessions which are none prescriptive but also use analogies which directly relate to students' experiences of the world particularly when involving complex equations and maths. Teachers should also emphasise the more interesting and 'sexy' side of physics such as astronomy:

> *I think we should do more about Black Holes…things like that.* Its interesting and better than maths. I might like maths in physics if we did about space travel and maths to do with that because its sexier and more interesting.
> (student).

All students interviewed indicate that both science and engineering suffer from a lack of 'identity'—particularly engineering. The students believe that even though current issues in science are generally well published/discussed through the media (engineering issues less so) sport and general politics are presented and discussed through more up-beat contexts and approaches, and usually for longer periods or slots on the television news and other programmes. The students suggest that science and engineering news items are often presented through negative and narrowly defined images and explanations citing coverage of the cloning and hospital super bugs issues as relevant examples. Presenting the positive benefits of science and engineering is seldom the main focus of the large majority of media coverage—instead, media focus prefers to concentrate on the more contentious issues and often present negative images that influence societies image of science. Sporting and political issues, however, are presented as exciting, interesting and more relevant to students and the general population even if the issue has a negative context.

Forces and atoms, for example, are viewed by the students as topics that do not have immediate relevance to their lives. Therefore, students do not recognise the specific identities and importance of science regarding their role in society as much as they do with politics and, particularly, sport—even though they believe they are important to the economic stability of the UK:

> When you see things about science on telly, on the news its *boring and complex. They don't make it exciting it just seems like no one really cares because they don't believe it effects them…even the newsreaders. But with sport..everyone* has an in*terest in who's winning and playing…the presenters* look interested in which team has won (student).

All students suggest that a more informed knowledge of the wide range of science and engineering professions, practice and environments, together with more interesting and

positive representation through the media of contemporary scientific issues would help them to relate to the identities science and engineering fields better, which in turn would help them accept their relevance to, and location within, society. Also, the majority were surprised to learn that they did, in fact, know a practising scientist or engineer when informed of some professions such as surveying, architecture, mechanical engineering and chemical engineering and also that their doctor and dentist are practising scientists.

All students express their enthusiasm for gaining a greater awareness of the day-to-day operations and duties of science and engineering professionals as well as career routes. Students are keen to understand what professionals do from the moment they enter their workplace to leaving at the end of the day in order to enhance their understanding of the variety of activities involved across the range of science and engineering professions:

> It would be good to visit a university or somewhere to *To see what they do. It's a day out and exciting to see* (student).

> Engineers make a product and mend things...that must make them feel good. I don't know much about how they decide what to do and how they do it though (student).

The large majority of students identify with the stereotypical images of science and engineering as being 'white lab coats and test tubes' and 'oily overalls and spanners' respectively. These perceptions are compounded by a lack of knowledge of professions and practice in the respective fields and influenced by media presentations and society in general.

The students agree that they would like detailed careers information on a regular basis and feel that it would be useful, where possible, to link this to specific subject content being taught. Students suggest they would benefit if teachers are able to utilise experts in the classroom at a time where the experts' particular specialist knowledge would greatly enhance the concepts being taught:

> *When we're doing things like gases if an expert is in school* to help us they could show us why we use gases and how *they use them in their jobs…that would make it [concept]* really interesting (Student).

Students state that having experts come into the school as positive role models would be useful in helping teachers to provide specific careers advise, up to date contexts for subject content, an identity for science and engineering through effective role models and a 'real' professional to relate to:

> It would be good to ask them questions about their jobs and find out what they do, how they do it, how much they get paid... things like that...and how they learned to do it (Student).

Students from two schools in particular indicate that they would benefit from regular, structured interventions from the careers service from as early as Year 8. They state that advice offered to them is too little, too late with the bulk of the input from careers guidance professionals delivered in their final year of compulsory schooling.

> Once every two months would be good or maybe a few times a year. They [advisors] could choose a different profession each time. But they would have to do it in detail, not like now where they just tell you bits like what subjects are needed (Student).

Discussion

While questionnaire results show students' perceptions towards classroom science as, largely, not difficult to learn, responses from interviews indicate that these students view physics as a difficult and complex subject. The students also suggest that topics such as forces have little relevance to their life experiences. However, they do acknowledge that there are interesting topics within physics. School-based educational experiences have a strong influence on students' decision making about their further study and career choices. Therefore, if pupils perceive physics as *'too hard'* and not relevant to them it is unlikely they will consider further study and career options related to this subject. Biology, on the other hand, is viewed

as *'easier'* and *'more meaningful'*. This is reflected in national statistics which show an increase in students studying bio-medical related subjects in FHE (DfEE, 1999). Students suggest that the application of concepts from biology is transparent and recognisable to them in an everyday situation. While physics and chemistry have few immediate linkages with their everyday lives.

A key issue to emerge from the focus group data shows that students would engage with physics better if the subject was 'sexed up' through more involvement with practical sessions that challenged them with a non-prescriptive approach, inclusion of greater relevance through stimulating analogies and subject content which directly relate to their personal experiences of, and interests in, the world. This issue is also highlighted by students in suggesting that engineering has a lack of 'identity' for them and should be presented by the media through a more positive and enthusiastic approach.

While pupils agreed that examples of engineering are all around them they feel that little is made of the success and benefits of advancements in engineering within the classroom and through the media in comparison to other fields. This may be one of the reasons why students are surprised to learn that the majority of them know a practising scientist or engineer—if they take little interest in fields which they believe suffer from a *'lack of identity'* they are less likely to be aware of professionals and practice within those fields. However, this latter issue is much more likely to be influenced by the students' lack of exposure to detailed careers information.

Students also recognise that having access to practising scientists and engineers would promote their interest and enthusiasm towards science and engineering. Students indicate that visiting professionals can provide valuable information regarding career and study

routes, pay and conditions, and duties/roles within an organisation. They suggest that an expert in the classroom would help to provide a relevant context for subject content and make classroom activity more exciting. They also suggest that access to professionals and their workplaces through school visits would be an invaluable vehicle for them to gain greater knowledge and understanding of specific professions and workplace environments. However, given the reported lack of effective role models in SET fields it is difficult to envisage how schools and experts will collaborate in a sustainable way.

Conclusions

The findings presented in this report constitute an insight into students' perceptions of science and engineering. However, the research provides only a snapshot and much more investigation is needed to complete the picture. Although other authors have reported work that focuses on critical influences such as gender differences and parents' perceptions, insight into the perceptions of families who do not have a tradition of entering FHE and the recruitment and retention of high quality teaching graduates warrant in-depth attention. In order to fully understand the problem of influencing more young people to consider further study and career options in science and engineering many more questions need to be asked.

Notwithstanding, the data from this research provides a contemporary record of how school students view science and engineering. It highlights students' apparent interest in science but lack of enthusiasm for school science education that pays little or no attention to science related issues that students encounter throughout their daily lives. While contextualising school science content and using relevant analogies are not new issues in research on teachers' practice (Clarke and Yinger, 1987) these pupils have cited it as particularly important to them. Furthermore, participating students highlight the impact on them of

restricted involvement in practical/hands on sessions in classroom science. The science curriculum is heavily content loaded which reduces teachers' opportunities for engaging students in practical sessions. In contrast the Design and Technology curriculum places priority on hands on activity with much less theoretical input. As physics and design and technology have much in common through maths and shared concepts it would be of benefit to students if school departments collaborated to integrate subject content through, for example, project work which combines concepts and practices from both areas.

Of great concern are the students' perceptions regarding careers input through school science. It is clear that students need greater input from careers professionals that focuses on specific information about science and engineering careers, such as pay scales, job descriptions, routes to employment/qualifications and the range of careers within science and engineering. The careers service appears to offer little or no support for KS3 students, instead concentrating efforts on KS4 students when other influences have already made an impact on students' choice of subject options and probably their further study and career decisions.

Despite changes to the curriculum, policy developments concerning the ways teachers should practice, the way teachers should view Continuing Professional Development (CPD) as a tool for accelerating expertise and best practice, and changes to assessment methods, a stark warning emerges from the students' responses to this study. Contemporary science lessons demonstrate many similarities with the ways secondary science was taught a century or more ago. These students are demanding a twenty-first century identity for science and engineering through a sexing up of physics and engineering related content that will both interest and enthuse them and possibly inspire them to realistically consider science and engineering related careers.

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