Learning to Love Science:

Harnessing children's scientific imagination

A report from The Chemical Industry Education Centre, University of York
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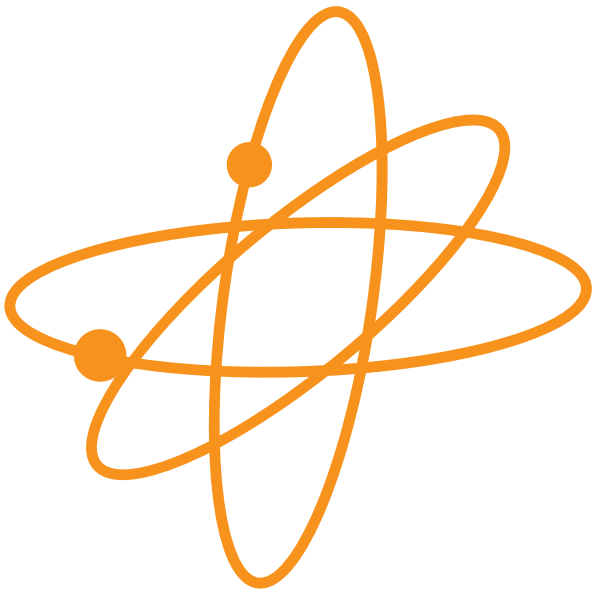
Shell
Education Service



Executive summary

Science, technology, engineering and mathematics (STEM) industries are of strategic importance to the future development of the UK economy.

This report explores school students' attitudes to science to establish why many disengage with the subject and what can be done to reverse this trend. It examines when and why pupils "switch off" from science and the extent to which the UK is missing out on a potential pool of scientists as a result.

The report builds on the wealth of previous research in this area and includes new, previously unpublished, research commissioned by Shell Education Service and conducted by specialist youth research company, Dubit. During the summer term, 2008, a poll of 4,000 children aged 9-14 was carried out by Dubit and 27 interviews with students, teachers, graduates and employers were conducted by the Chemical Industry Education Centre at the University of York.

This report captures this work to bring fresh perspective on one of the biggest educational challenges facing the UK today. A skilled workforce is essential in achieving the aim of a high technology, high value-added economy. But the numbers of school students choosing to take physical sciences post-16 has fallen over the last 25 years.

Shell research shows that, as young as nine years old, over half of those polled had a firm idea about their future occupation. Over a quarter (28%) said they would study and work in science in the future. This proportion remained relatively stable over the age range questioned. However, responses in the poll and analysis of existing examinations data, suggest that a large number of students who could potentially follow a science-related career are rejecting this option by the time they reach the age of 16.

Those students surveyed, who had rejected science as future option, said that they did not want to sit in a laboratory all day or that they found science boring. It must be a major concern that many students do not have a good sense of what is involved in science-related jobs. The challenge therefore is to engage and inspire these students so that science becomes a viable choice that they reconsider.

Many existing studies and the new Shell research, indicate a decline in positive attitudes towards science as children progress through secondary school. Children at 14 years old see less relevance of science to the real world, find it less inspiring, enjoy less practical work and feel they have less opportunity to use their imagination in science than children at nine years old.

Despite this decline in positive attitudes to science at secondary school, a study by the Organisation for Economic Co-operation and Development (OECD) reported that the performance of students in science in UK secondary schools was well above the international average, although it also noted a spread of abilities in the UK with a considerable number of low-achieving students. There is a challenge, therefore, to ensure that the teaching of science meets the needs of all levels.

There does not appear to be just one single reason for the fall in popularity of the physical sciences but reasons include:

- a curriculum that is often perceived by students as being too theoretical and not relevant
- a poor understanding of the options offered by science-based careers in both students and some teachers
- a shortage of specialist science teachers, especially of physics in secondary schools

These issues have been recognised and are being addressed. The science curricula have been modified to promote opportunities for seeing science in a real life context. Programmes to recruit, retain and train teachers with a physics specialism are ongoing. Many companies are actively involved in promoting links with education and a national programme to promote STEM subjects has been initiated.

This report reviews the reasons why students 'turn off' from science. It explores some of the approaches which can inspire children with science and ensure we develop the rich source of skilled scientists so vital to the future development of this country.

Contents

Foreword from James Smith

Why is Shell committed to supporting science education?

Shell is committed to supporting science education because science holds the key to helping us understand the everyday world around us.

Science also has a key role to play in our economic future, and in helping to solve some of the most pressing challenges we face in the world today - including meeting growing energy demand in sustainable ways. A lack of skilled workers to drive the STEM industries forward could risk the loss of innovation and participation in this area by UK companies.

Expert leaders from the Shell Education Service visit over 50,000 primary school children each year, running unique, interactive, physical science workshops. They also organise family science days with local communities and support trainee primary science teachers, building their confidence and skills in teaching science.

We know that children are naturally excited by science through our work with the Shell Education Service. We want to encourage the movement of that childlike enthrallment to serious consideration of a career in science in more and more of our children.

We commissioned the *Learning to Love Science: harnessing children's scientific imagination* report to learn what might cause children to disengage from science and what is needed to maintain their interest. I hope it gives insight into how we can better communicate the diverse nature of science careers.

The research shows us that children as young as nine are already considering their future direction. This underlines the importance of engaging children with science early and we must ensure that, once children are excited by the world of science, we harness this early enthusiasm.

Industry has a role to play. Creating better links with schools to enable children to see science in action helps companies of all sizes - from the local to the international.

James Smith
Chairman, Shell UK

Introduction

Studying science opens up a world of possibilities and scientists play a vital role in the UK society and economy. Yet fewer students are opting to study physical and chemical sciences post-16.

This report explores school students' attitudes to science to establish why many disengage with the subject and what can be done to reverse this trend. It examines when and why pupils "switch off" from science and the extent to which the UK is missing out on a potential pool of scientists as a result.

The report builds on the wealth of previous research in this area and includes new, previously unpublished, research commissioned by Shell Education Service and conducted by specialist youth research company, Dubit. During the summer term, 2008, a poll of 4,000 children aged 9-14 was carried out by Dubit and 27 interviews with students, teachers, graduates and employers were conducted by the Chemical Industry Education Centre at the University of York.

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UK student entries into post-16 science 1990 – 2007

Before examining when and why students reject science, it is useful to first look at the proportion electing to study science after the age of 16.

In UK secondary schools, some form of science is compulsory up to the age of 16. Analysing post-16 subject choices shows the degree to which students are making a positive decision to pursue science.

Those choosing to do so has fallen over the past 25 years. Biology A-level has remained fairly stable but the proportion of students taking physics and chemistry has fallen considerably (figure 1). When looking at Scottish Higher subjects, biology has also seen a fall in line with chemistry and physics (figure 2).

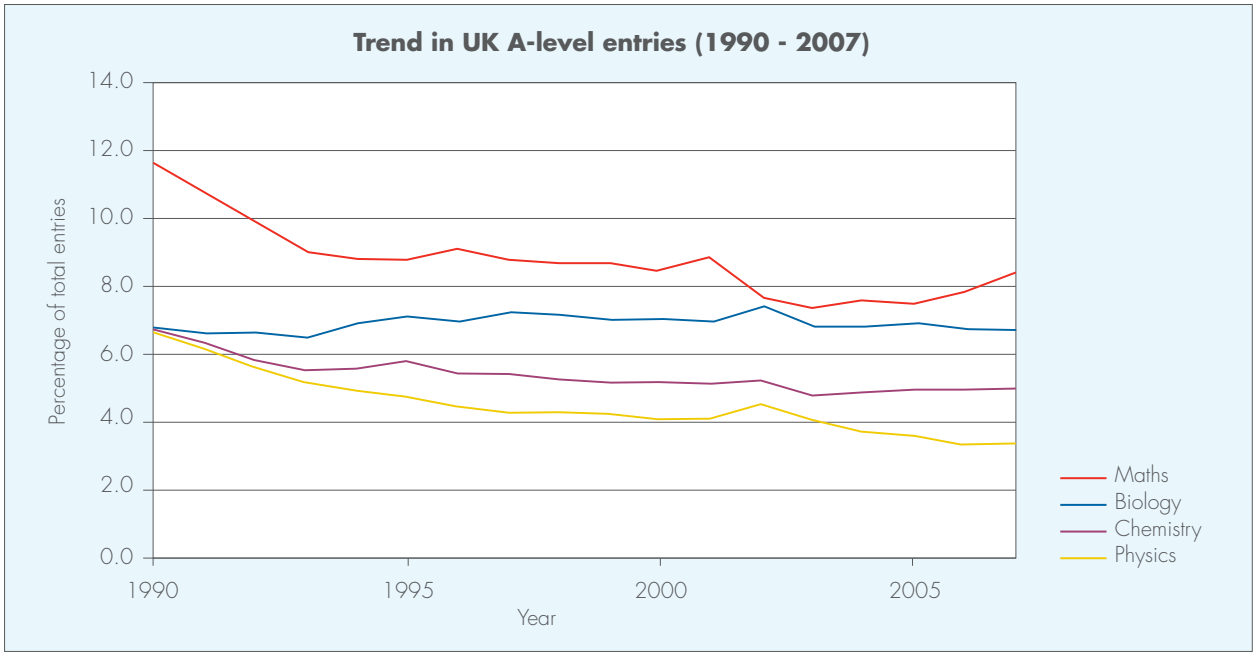
During the period of 2001 - 2007, biology and mathematics remained in the top four choices of A-level subjects. Chemistry has fallen from 5th most popular subject in 2001 to 8th in 2003, where it has remained.

Physics has seen its popularity fluctuate between 10th and 12th places. In 2005, around 375,000 science GCSEs were awarded at grades A*-C in either dual award or individual sciences. Yet two years later, only 40,000 students completed an A-level in chemistry and just 27,000 in physics[1].

In Scotland, over 23,000 students took Standard grade physics in 2006 but only 8,500 continued to study it at Higher level.[2]

The Shell poll revealed that 38% of 9-14 year olds agreed that science lessons at school were inspiring, however just 28% said they intended to study science and pursue a scientific career after the age of 16. This suggests that the UK is missing out on a pool of potentially thousands of new scientists as a result of school students not pursuing the subjects, even if they have an interest in science itself. The challenge is,

Figure 1: UK A-level entries (% of total entries)



Source: Joint Council for Qualifications (JCQ), annual statistics 1990-2007.

UK student entries into post-16 science 1990 - 2007 continued...

therefore, to ensure the potential of these inspired children is harnessed, while also increasing the proportion of children who feel inspired by science and reaching out to children of all abilities.

Figure 3 shows that whilst other STEM subjects remain popular choices in higher education, the proportion of physical science awards is below the all-subject average.

Choosing science

Over a quarter (28%) of nine year olds, and 29% of 14 year olds, in the Shell poll stated that they would study and work in science in the future. In a National Science Learning Centre survey, 50% of year 9 students said they would take one science subject after their GCSEs, with almost half stating their reason was to qualify for a particular job[10].

Students' perceptions are that it is more difficult to get higher grades in physics and chemistry, compared to other curriculum areas[3]. As post-16 qualifications are often chosen in relation to gaining entry into higher education or a particular career, if students feel they are less likely to succeed in science subjects, they are less likely to choose them.

It is unclear as to whether these perceptions match with reality as evidence on the relative difficulty of subjects is somewhat contradictory. A study conducted by the QCA concluded that the perceived 'soft' A-level subjects were no less demanding than the more established subjects[4]. However, a review of several studies in this area concluded that science subjects are more difficult at A-level than non-science subjects[5]. It is important to resolve this issue so that a clear message can be sent out which states that science subjects are of equal difficulty to all others.

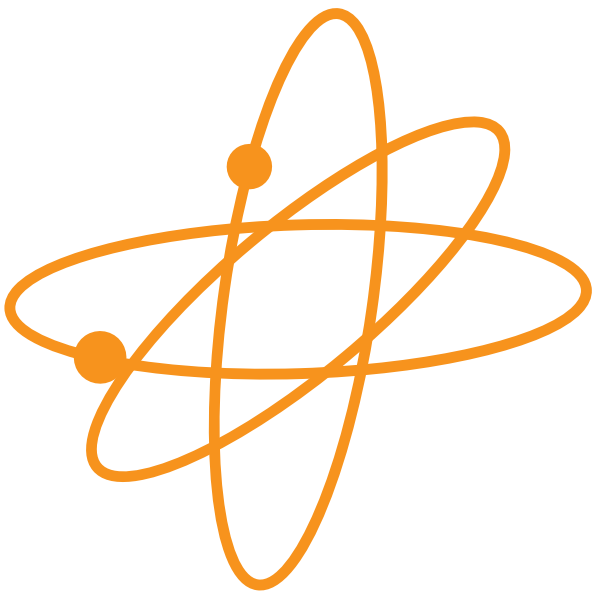
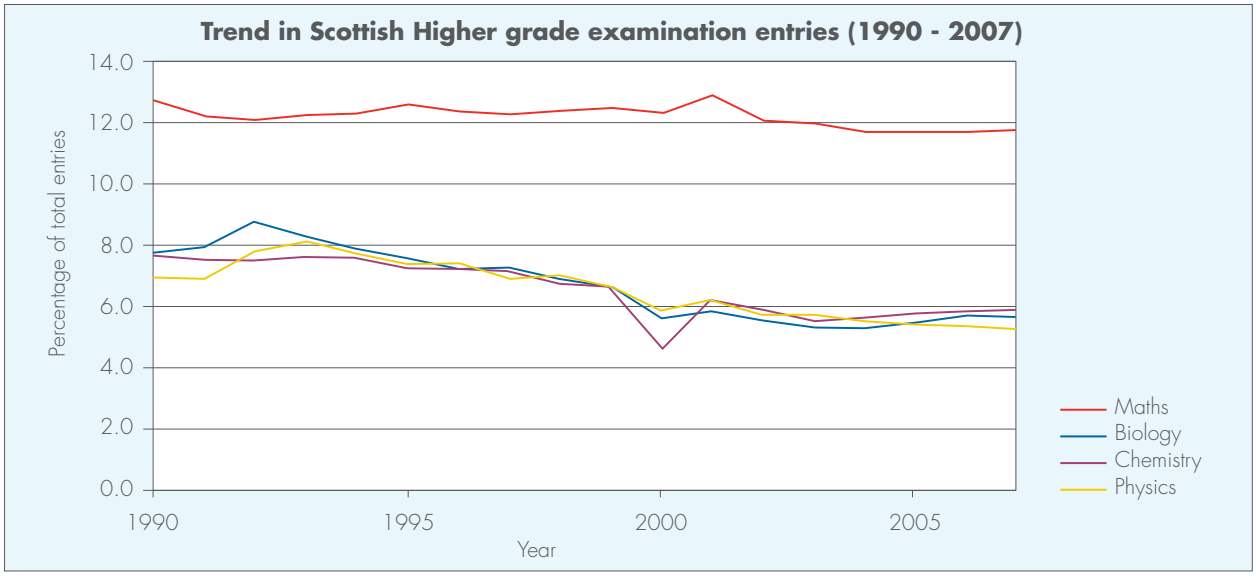


Figure 2: Scottish Higher Grade entries (% of total entries)



Source: Scottish Qualifications Authority, annual reports 1990-2007.

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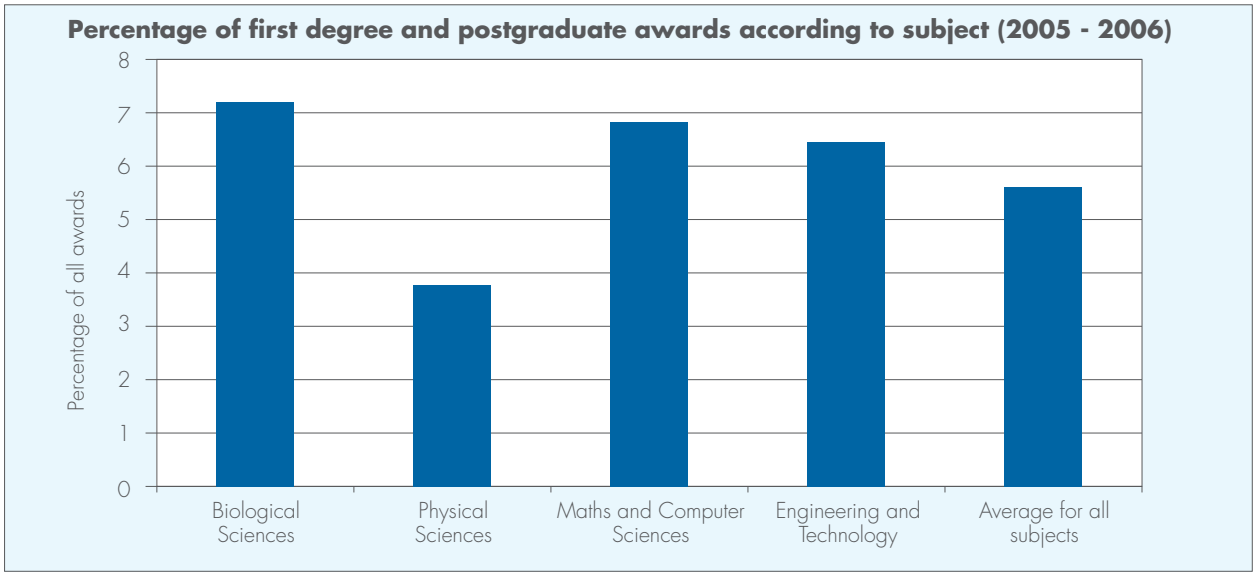
[1] *Joint Council for Qualifications, annual statistics and National Statistics.*
[2] *SQA (2007) Annual Statistical Report.*

Figure 3: Higher education awards by subject



Source: DCSF Education and Training statistics for the UK 2007

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[3] *Fitz-Gibbon, C (1999). Long term consequences of curriculum choices with particular reference to mathematics and science. School Effectiveness and School Improvement 1999, vol. 10, no. 2, p217*
[4] *Qualifications and Curriculum Authority (2008). Inter-subject comparability studies.*
[5] *Relative difficulty of examinations in different subjects (2008). Robert Coe, Jeff Searle, Patrick Barmby, Karen Jones and Steve Higgins, CEM Centre, Durham University.*

Scientific attainment in UK schools

It is apparent that the UK has school students of high scientific ability, but also that a considerable number that disengage from the subject.

In 2007, the scientific performance of students in UK secondary schools was described as considerably above the international average in a major study by the OECD[6]. The UK was placed 8th in a league table of OECD countries and 14th overall of the 57 countries examined. The report noted that the UK has a large spread of abilities with a "long tail of low achievers."

In a survey of 90 primary and 105 secondary schools, Ofsted[7] noted that teaching that is tailored to achieving success in examinations may not meet the needs of all students. It is understandable that teachers, especially those who are not science specialists, adhere to schemes of work which deliver success in SATs and examinations. This may be to the detriment of creative and inspirational teaching which engages, motivates and stretches students of all abilities. As one teacher comments:

> *"The biggest issue in primary schools is the amount of content of science we have to get through. Instead of just getting them out and doing lots of investigations, at the back of your mind you are thinking we have to get this covered otherwise they won't know it for their SATs at the end of year six."*
> - Primary school teacher

Current and imminent changes to the National Curriculum and the introduction of the Scottish Curriculum for Excellence may help to give teachers the flexibility to explore and adapt the curriculum. The success or otherwise of these changes will largely depend on the quality of teaching provided.

[6] *Programme for International Student Assessment (2007). Organisation for Economic Co-operation and Development (OECD)*
[7] *Success in Science (2008). Ofsted, reference: 070195.*

Tracking attitudes towards science in school

In the Shell poll of 4,000 9-14 year olds, only 6% rated science as their favourite subject, however this remained fairly stable across the age range polled.

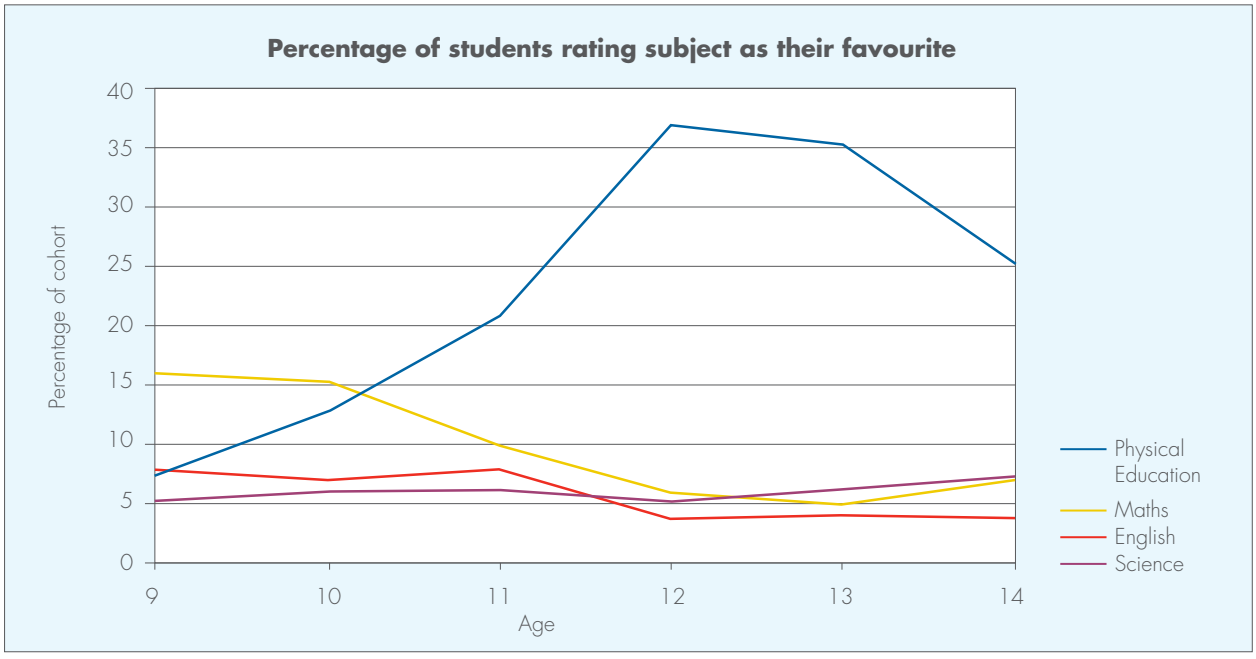
During interviews, primary and secondary students rarely mentioned science as their favourite subject. Numerous studies have demonstrated[1,8,9] a decline in students' attitudes to science from age 10 and it continues throughout the secondary phase. A typical response is that science becomes too theoretical and irrelevant to everyday experiences.

The Shell research explored the attitudes across the 9-14 age range. Figures 4 and 5 summarise a few of the key findings.

As can be seen from figure 4, Physical Education is not popular at primary school but becomes a favourite during the early secondary phase before falling as students get older. Maths drops in popularity until stabilising at around age 12; a pattern also reflected by English. The Shell poll did not find evidence for a decline in the popularity of science over the ages 9-14. Starting with 5% of students stating that science was their favourite subject and ending with 7%. Whilst it is a disappointingly low fraction of students who rank science as their favourite, these findings stress the importance of engaging students and capturing their enthusiasm for science in the primary phase. All subjects are not shown on this graph, to simplify the data, but it is worth noting that Art was the most popular subject for primary-aged students, and that Religious Education and Geography were consistently the least popular subjects with students of all ages.

The poll did find that students generally started to have less positive attitudes to science lessons as they got older. Figure 5 shows the

Figure 4: favourite subjects



[8] Osborne, J., Simon, S. and Collins, S (2003). Attitudes towards science: a review of the literature and its implications. International Journal of Science Education, vol. 25, no. 9, pp1049–1079.
[9] Bennett, J. and Hogarth, S. (2005). "Would YOU want to talk to a scientist at a party?": Students' attitudes to school science and science. University of York, Department of Educational Studies Research Paper 2005/08

Tracking attitudes towards science in school continued...

percentage of students in each cohort that agreed with the following statements:

- I enjoy science as I get to do lots of fun practical work
- I enjoy science as I can use the things I learn in my everyday life
- Science lessons are inspiring and help me to think in a different way

The data shows that students feel science lessons become less inspiring and less relevant as they get older. This supports the findings of other reports. An increase in the enjoyment of science lessons, linked to the level of practical work, initially increases in the early secondary phase, possibly as students are introduced to a wider range of equipment in specialised laboratories. Interviews carried out in our study underlined that the most popular part of the science curriculum is the practical work, while there is far less enthusiasm for written work.

This is exemplified by the following statements made by year 9 students when asked to describe the science they enjoyed:

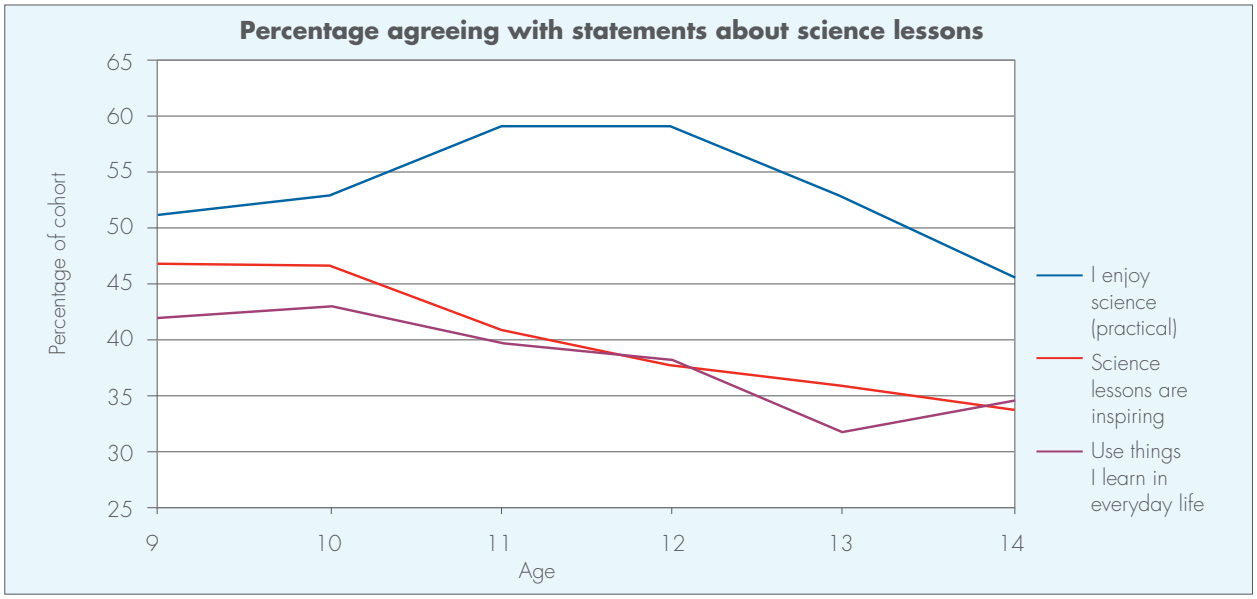
"It's practical and we get to do stuff rather than just sit there, I learn more because we've done it ourselves rather than just reading about it."

"That calcium stuff - when you put it in the water - that was fun. But actually writing down the equation - that's the boring bit."

In a survey of over 1,000 UK secondary students by the examination board OCR in 2005, over 50% said science lessons were boring, confusing or difficult and that experiments are the best thing about learning science.

However, 77% of students in this study said that their school science would be useful to them in the future. These findings are echoed in a report by Lyn Haynes that also suggested students became disinterested in science due to a curriculum that is perceived as boring and irrelevant and school science not living up to students' expectations as they move from the primary to the secondary phase (less practical and more written work). This report also cites

Figure 5: The proportion of students agreeing with statements about their science lessons



uninspiring teaching as a contributory factor. An arts graduate interviewed during our study commented that school science was:

> *"Just pages and reams of notes. I'd got nothing to relate it to."*

Statements like these demonstrate a barrier to increasing the uptake of science post-16. Although students think science is useful, they are not inspired by it. New GCSE curricula attempt to address this, and giving students experience of the real-life applications of science may encourage more to consider science as a future occupation. The challenge is to integrate an investigative approach, which gives the freedom to explore ideas and concepts, into a curriculum that retains sufficient scientific content.

Recruitment and retention of science teachers

Some non-specialist science teachers struggle to teach a subject area in which they are not fully confident. Possibly as a result of this, uninspiring teaching has been cited as a reason for students becoming less enthusiastic about science[10].

In 2006, almost one in ten secondary schools reported one or more science teacher positions unfilled[6]. Recruiting and retaining specialist physics teachers is a particular problem.

In 1983, 30% of science teacher trainees were physics specialists, but by 2007 this had dropped to just 12%[11]. In addition, in English state-sector schools, 41% of up-to-16 schools had no physics specialist teachers and 11% of schools that teach up to 18 did so without a physics specialist[8]. Financial incentives and training for current teachers aim to redress the loss of physics specialists, but tackling the shortage of physics specialists, especially in the state sector, must remain a high priority.

Continuing professional development (CPD) of science teachers is also being addressed. A report from the Wellcome Trust[12] noted that half of the secondary science teachers they interviewed had not participated in any subject-specific CPD in the previous five year period. In 2004-5, a nationwide network of science learning centres was established to provide high quality CPD for science teachers and technicians. Recently the Wellcome Trust, with a range of industrial partners, announced a fund of £30million to provide further CPD opportunities at the National Science Learning Centre.

Ongoing efforts must be maintained to encourage science teachers to see CPD as an integral part of their job and to take advantages of the development opportunities available.

The Scottish Government does not report any teacher shortages but there is an increase in recruitment of maths teachers to help reduce secondary class sizes. The Scottish Survey of Achievement (2007) commented that a significant number of pupils are not achieving expected levels in scientific knowledge and understanding, particularly in Primary 7 and Secondary 2. The report also examined teachers' self-assessment of their level of confidence in teaching science. In primary schools, just over half reported they were confident in teaching physics whilst in secondary this rose to 90%. Professional development opportunities in science were taken up by 60% of primary teachers within the preceding four years while at secondary level, almost two thirds had taken two or more CPD opportunities.

Choosing science, choosing a career

Studies[13,14] suggest that a future career in science was one of the main drivers for making subject choices post-16. To improve the uptake of science subjects, it is therefore important to show students the opportunities in science-based industries.

The Shell poll revealed that over half of nine year olds (52%) already have a firm idea of what career they want to pursue in the future and a further 32% said they have some idea of their future career. Although 10% of the students stated that becoming a doctor was their first choice of career, only 6% said it was to become a scientist. Of those that said they did want to become a scientist, 72% were boys and 28% were girls. Gender stereotypes

[10] *Lyn Haynes (2008). Studying STEM: what are the barriers. A literature review of the choices students make.*
[11] *Physics in schools IV: supply and retention of teachers (2008). Alan Smithers and Pamela Robinson, Centre for Education and Employment Research, University of Buckingham.*
[12] *Believers, Seekers and Sceptics: What teachers think about continuing professional development (2006). Wellcome Trust.*
[13] *Rodeiro (2007). A-level subject choice in England: patterns of uptake and factors affecting subject preferences. University of Cambridge Local Examinations Syndicate.*
[14] *Cleaves (2005). The formation of science choices in secondary school. International Journal of Science Education, vol. 27, no. 4, pp471-486*

Tracking attitudes towards science in school continued...

continue to influence choices, with sciences perceived as a male-dominated occupation according to a study by the Institute of Employment Studies[15].

Perhaps the biggest issue to address is that a career in science has little appeal to both boys and girls according to a study by Sjoberg and Schreiner[16]. A common perception is that science is abstract, theoretical and not engaging.

In the Shell study, over 1,500 students rejected science as a career choice. This group were then asked to choose statements which described their reasons. Typical responses saw science as a job that was based in a laboratory all day, cut off from the world and with little chance to use communication skills. Interestingly, more nine year olds than 14 year olds are put off science careers because of a perception that other jobs are better paid. When asked to describe a scientist, this response from a year 9 student was typical:

"Person with a big white lab coat, with glasses, messy hair and likes to play with chemicals."

Improving students' understanding of the real-life applications of science and the people working in these areas will help to encourage more students to consider science-based careers.

Interventions as early as the upper primary phase are needed, given that opinions on science can be formed as early as 10-11 years old[1]. By 13-14 years old, nearly 80% of students questioned in an NFER[17] report had an interest in working in a particular career and over half said that their career choice had been influenced by how it was portrayed in the media.

When primary school children were interviewed for this report, they consistently demonstrated that they had thought about their future careers and were often very specific in their aims. One primary school teacher, when asked the best time to inspire children about science stated:

"Year 5 and year 6 is the crunch. If we get it right then, we have got it right for the early years of secondary. It sets the scene for them in high school. That's really important."

Science in context

Using real-life contexts for the teaching of science has considerable benefits in terms of improving students' attitudes to school science[18]. When interviewed, teachers recognised the value of working with science-professionals and one primary teacher commented:

"I think that's the key. We need to get more children seeing science in the workplace..... That just amazed them, the lights were on in their eyes."

The need to make school science relevant and engaging has been a driver of curriculum developments for many years. In the 1980s Nuffield chemistry and physics courses were amongst some of the first to lead the way by encouraging an investigative approach to science. Since 2006, new GCSE curricula aim to look at the real-life application of science and develop scientific literacy.

In Scotland, the development of the Curriculum for Excellence aims to promote an approach which helps students understand the impact that science makes on their lives and the lives of others. Whether these changes will result in more students opting to choose science for their post-compulsory study will be seen over the next few years.

[15] *Pollard, E. et al (2003). Ready SET Go A review of SET study & careers choices. The Institute for Employment Studies.*
[16] *Sjoberg, S. and Schreiner, C. (2005). How do learners in different cultures relate to science and technology? Results and perspectives from project ROSE (The relevance of Science Education). Asia-Pacific Forum on Science Learning and Teaching, vol. 6, issue 2,.*
[17] *National Foundation for Educational Research (2005). Factors influencing year 9 careers choices. Report for the Engineering and Technology Board, 2005.*
[18] *Bennett, J., Lubben, F. and Hogarth, S. (2006). Bringing science to life: a synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. Science Education, Wiley InterScience*

Schools-Industry links

Many science-based industries are involved in the production of materials and programmes to enrich the school curriculum and create schools-industry links[19].

The UK Government has launched a number of initiatives under the science, technology, engineering and mathematics (STEM) agenda[20]. These include a programme which has set up 250 after school science clubs, which help to show science in a real life context through activities such as investigations and visits to businesses.

A three-year national campaign to promote an understanding of STEM careers to young people, parents and teachers launched in 2008. In partnership with subject associations, employers and higher education, the aim is to show that studying STEM opens up a wide range of interesting and exciting career opportunities.

The science, technology, engineering and mathematics network (STEMNET) aims to encourage young people to enter science-related careers at all levels. One of its activities is the Science and Engineering Ambassadors scheme which brings science professionals into primary and secondary schools to showcase their work. There are over 18,000 ambassadors from more than 1,000 employers and universities that promote science in schools by activities such as supporting science clubs, providing work-based placements and mentoring students.

Primary school is not too early

Interventions in the primary phase have positive effects on children's views of science and the effects can be long-lasting[21]. Context-based activities help to increase motivation and enhance the relevance of the science studied in the classroom. One such programme, Children Challenging Industry, consists of classroom-based investigations linked with science-based industries. The programme culminates in a visit to a local industrial partner to see the science in action. Following participation in the programme, children's understanding of science-based jobs is much more realistic and positive. Increased awareness is also seen in the class teachers.

It could be argued that intervention at such an early age may have little lasting effect. However, a five-year follow-on study[22] published in 2004 looked at a sample of children involved in the programme. It showed that nearly a third of the pupils remembered the classroom activities five years later and nearly two thirds remembered their industrial visit. Positive or negative experiences of primary science can carry through for many years[23].

Another programme that involves industry in supporting classroom-based teaching and learning is provided by the Shell Education Service (SES), established by Shell more than 50 years ago. SES supports the teaching of science to young people in a hands-on investigative way. SES deliver science workshops to engage primary children with the subject and equip primary teachers with skills and confidence to continue to inspire their classes long after the workshop team has visited. SES activities reach over 50,000 primary children every year.

Secondary school students also value contact with industry[24]. Experiencing the 'human' aspect of a scientist at work helps to break down negative preconceptions. The model of a classroom based activity linked with contact to industry could be developed to encourage a greater understanding of real-life science and related career opportunities. One secondary teacher in our study reflected the views of others in that:

"They [the students] have to see them [industrial personnel] as real people. Otherwise it is just another video or case study in a text book. They think it applies to someone else."

[19] *Department for Education and Skills (2003). Science, Technology, Engineering and Maths (STEM) Mapping Review.*
[20] *Department for Innovation, Universities and Skills (2007). Science and Innovation Investment Framework 2004-2014: Annual Report.*
[21] *Parvin, J (1999). Children Challenging Industry: the research report. Chemical Industry Education Centre, University of York.*
[22] *Evans, C., Hogarth, S. and Parvin, J. (2004). Children Challenging Industry: analysis of CCI project data 5 years on.*
[23] *Cerini, B., Murray, I. and Reiss, M. (2003). Student review of the science curriculum: major findings. Planet Science, the Science Museum and the Institute of Education, University of London.*
[24] *Stagg, P. (2007). Careers from science. Science Education Forum.*

Schools-Industry links continued...

Attracting recruits into the chemicals and related industries

The sector faces a dilemma; how to attract new entrants when recruiters often ask for experience and highly job-specific skill sets. Additionally, changes in markets and increases in productivity mean that the workforce is shrinking[25]. One Human Resources Manager from the chemical sector stated:

> *"We used to have apprentices in the past. Because of headcount reductions we were training apprentices and then not being able to employ them."*

A report by COGENT[5], the sector skills council for the chemical, pharmaceutical, gas, oil, nuclear, petroleum and polymers industries suggests that personnel will be needed to replace those leaving due to retirement. Projections anticipate a need for recruits at Scottish Vocational Qualification (SVQ) and National Vocational Qualification (NVQ) levels 2-3 in process, maintenance, skilled trades and operations technicians. At graduate level, the study highlighted a need for entrants in chemical engineering, chemical process and energy engineering, chemistry and physics.

A CBI survey[26] showed that 59% of employers had difficulty in recruiting STEM-skilled individuals. Experienced graduates and technicians were in especially short supply in the energy and water sectors.

STEM skills are highly transferrable, so school-leavers and graduates may be more attracted to other sectors, such as commerce and finance, if opportunities are not available. Employers may need to re-examine their strategies to attract suitable recruits in an increasingly competitive skills market.

[25] *Annual Business Inquiry (2008). National Statistics UK.*
[26] *Taking stock: CBI education and skills survey 2008.*

Real science, real people, real opportunities

As outlined earlier in this report, the image of a scientist, working in a laboratory, wearing a white coat and mixing chemicals persists in both school students and, to a certain extent, their teachers.

To reverse this, the STEM-related industries must maintain efforts to communicate the range of opportunities and roles that are available to scientists. As well as targeting secondary school students, interventions in the upper primary phase should form an integral part of an overall programme of activities.

Many companies are already involved in educational programmes and links with schools. Great strides are being made to promote an understanding of STEM-related careers, with the majority being aimed at teachers and school students. Perhaps additional effort must be put into encouraging and developing industrial personnel to enable their communication of the excitement of real-life science.

Making school links productive: training local industry partners

Direct interactions with people in a STEM-related industry are a powerful experience for school students. However, they must be engaging and active rather than, for example, offering passive, traditional slide show talks. As year 10 students noted:

"You're not going to learn a big load of writing off the slide show. There's no point."

"When we had that big load of experiments and we all had to switch round and do each experiment. That was good."

Working with young people requires a certain understanding and approach which may be alien to personnel working in industry. After all, why should scientists instinctively have the skills necessary to work with groups of school students without training and guidance?

Successful industry-schools links are well-planned, active, engaging and at an appropriate level for the students involved. Hands-on, practical activities can fire students' natural curiosity. Successful site-visits can give experiences that live with students for many years. One year 6 student, who had visited industry as part of the Children Challenging Industry project, stated:

"The part I enjoyed most was mixing the paints because I got really close to the peach colour on the card."

This same student added that he had been considering a career as a writer, but was now considering a career in industry.

To ensure successful school links are developed, industry partners should seek to be involved in schemes which offer training and guidance to industry personnel, such as the Children Challenging Industry and the Science and Engineering Ambassador schemes.

Many larger companies have education officers and active programmes. However, it is often the smaller, local companies that are accessible to schools who wish to develop an ongoing link with their local employers. Unfortunately, smaller companies may feel they are unable to release personnel or may not appreciate how they can make a difference with such a link.

Schools links have many benefits. Students, as well as their family and friends, become much more aware of the work of local employers. A productive collaboration will enhance the company's image within the local community and may well inspire the wealth-generating scientists of the future.

Incentives, possibly of a financial nature, and greater support should be made available to encourage smaller companies to become involved in schools links. This could involve providing guidance and support in working with school students and developing suitable activities. As a result, companies may feel more able to offer experiences such as site visits, work placements and school-based activities.

Rising to the challenges

There are many factors that influence whether school students decide to continue with science post-16, but one of the most important drivers is the entry into a STEM-related job.

Students as young as nine years old have formed opinions about their future careers. Activities to engage teachers and students with the opportunities offered by a science-based career should start in the upper primary and continue into the secondary phase.

There is a decline in positive attitudes towards science from ten years old which continues throughout the secondary phase. This is largely due to a perceived decrease in the amount of practical investigations conducted. Students often see the curriculum as being too theoretical and distant to their personal experiences.

Developments in the science curricula, which aim to put school science into real-life contexts and to offer greater freedom to explore an investigative approach, are being implemented to address these matters. The changes are to be welcomed and their impact will become apparent over the coming years.

High quality and inspiring teaching encourages students to have a positive attitude to science. It is concerning that there remains a shortage of highly qualified and specialist teachers of physical science. Programmes to provide quality professional development and encourage more highly qualified entrants into the profession are in place and their success is essential if the trend of losing physical science teachers is to be reversed.

One of the most important resources in encouraging more students to continue in science are the employers themselves. Many companies already have educational programmes and a range of activities are also supported through professional associations. Strategies should be developed to encourage small companies, working in the science sector, to become actively-involved in building sustainable links with local schools. This will enable students to see real people, working in real jobs that could realistically be a future career option.

Notes from the authors

The authors would like to express their thanks to the following organisations, whose students, teachers and personnel contributed to the interviews involved in this study:

Brookburn Primary School

Contract Chemicals

Hill of Beath Primary School

Liverpool Hope University

North Manchester High School for Girls

Pilkington Group Ltd

SABIC Innovative Plastics

Shell UK Ltd

Solvay Interox

St Andrew's High School

Temple Primary School

University of Manchester

The report was produced by the Chemical Industry Education Centre at the University of York combining analysis of existing research, interviews with students, teachers, graduates and employers, and the results from a poll of 4,000 children. The polling was conducted by Dubit, CIEC were not involved with the collection and analysis of this data.

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