INDUSTRY AND THE SCHOOL CURRICULUM

Across Science, Technology, Engineering and Mathematics

Report by the STEM-ED Group, April 2007

Table of Contents

FOREWORD

ACKNOWLEDGEMENTS

The work for this report was carried out by STEM-ED Scotland and the authors would like to thank our sponsors for funding the project. Our sponsors are Glaxo Smithkline, the Institution of Engineering and Technology, Lifescan Scotland, Rolls Royce, the Royal Society of Chemistry, Sun Microsystems and the Weir Group. We are also very grateful for the help and advice of our Advisory Group and especially to Nigel Akam for his supportive and helpful input throughout this and other projects.

Glaxo Smithkline | Inst of Engineering & Technology | Lifescan Scotland | Rolls Royce | Royal Society of Chemistry | Sun Microsystems | The Weir Group

STEM-ED SCOTLAND

STEM-ED Scotland is a collaborative partnership aiming to champion world class education world class education in Scotland in science, technology, engineering and mathematics.

The Authors

Professor John Coggins is Vice Principal for the Faculties of Biomedical & Life Sciences, Clinical Medicine and Veterinary Medicine at the University of Glasgow. As a member of the Scottish Science Advisory Committee he was the author of their earlier report "Why Science Education Matters"

Professor Alan Roach, an emeritus professor from the school of Engineering and Science at the University of Paisley, is Secretary of the Deans of Science and Engineering Scotland and Secretary of the Centre for Engineering Education & Development.

Moira Finlayson, previously Head of Science and Mathematics at Kilmarnock College, is STEM-ED Coordinator and was the full time researcher for this project.

STEM-ED Scotland
c/o Institute of Biomedical & Life Sciences
Wolfson Link Building
University of Glasgow
Glasgow G12 8QQ
Web: http://www.gla.ac.uk/stem

April 2007

INDUSTRY and the SCHOOL CURRICULUM
Across Science, Technology, Engineering and Mathematics

ABSTRACT

This Report reviews views from Scottish industry of how schooling could aim better to support their needs in the fast-moving and globally competitive economy. It is based on a survey coupled with an extensive review of other relevant reports.

The single most important concern of employers is to improve the attitudes of young people towards the world of work. Commitment to work, initiative, self-confidence, perseverance and a creative approach are seen as qualities that should be nurtured through school. Successful recruits need readily to engage with, and show respect for, work colleagues and supervisors, whilst also being prepared to take personal responsibility and independent action. There is considerable concern that the nature and significance of engineering, the importance of industry and the fulfilling and well-rewarded careers available are rarely appreciated and seem not to be reflected in careers advice.

Next in priority is to enhance basic and transferable skills, notably of numeracy, literacy and both oral and written communication. Better developed technical and practical abilities are sought. Valuable employees require also to have well developed problem solving, team working and planning skills.

Employers urge that every effort should be made to improve capabilities in basic mathematics. They are alarmed about decreasing trends in numbers studying sciences and about the very low exposure of engineering in schooling. They believe that all young people should gain some understanding of engineering and of the impact of science on life. Priority should be given to developing a breadth of understanding of basic knowledge and to an ability to apply this in new contexts.

The concerns of employers differ in detail for recruitment at different levels. There is alarm about the poor work-readiness of many school leavers applying for operator or skill-seeker levels of entry. At the Modern Apprentice level of recruitment it is felt that those applying represent a less well-qualified cross section of school leavers than previously. At graduate level there is concern about the supply of engineers and physical scientists, about their lack of appreciation of industrial roles, and about deficiencies in self-confidence and collaborative communication skills. In these latter respects a number of senior employers compared Scotland unfavourably with Ireland and England.

The findings are consistent with, and also complement, views derived from earlier work with universities. They are relevant to ongoing work by the Scottish Executive following their report *A Curriculum for Excellence.* We intend also to use the findings, alongside earlier studies, and with teacher collaborators, as a starting point for an independent study of potential "Green Field" models for a future coherent curriculum across the range of STEM disciplines, developed afresh from 21st century perspectives. The Scottish Executive has agreed in principle to support this future work over a three-year period.

1. OVERVIEW REPORT AND CONCLUSIONS

1.1 The wider context

STEM-ED Scotland is a collaborative partnership among individuals and groups reflecting a range of interests including schoolteachers, universities, industry and public sector agencies. It aims to bring stakeholder perspectives together, in order to champion world-class educational provision in Scotland for science, technology, engineering and mathematics disciplines (STEM), at all levels.

Publication of the document *A Curriculum for Excellence (ACfE)* provides a unique opportunity in Scotland. That paper commits the Scottish Executive to a fundamental and rolling review of the entire school curriculum from age 3 to 18, driven by overarching principles that seem wholly amenable to new and coherent visions of STEM education as a whole. School education is the foundation on which all else builds, and STEM-ED Scotland is at this stage concentrating on this level, aiming to ensure that the current opportunity is fully exploited.

Our first study project was conducted in 2004, simultaneously with the Scottish Executive's review that led to ACfE. Funded by the Education Department we reviewed academic opinion across science, engineering, medical and computing fields in the 13 universities in Scotland, on what were perceived as the main priorities for school science education. There was an astonishing level of consensus, and clear concern to see greater coherence in education across the STEM range of disciplines.

A report of that project[1] was widely circulated in Scottish schools and attracted positive responses. This led to involvement in STEM-ED by leading teacher members of the Association for Science Education in Scotland, the Scottish Technology Teachers Association and the Scottish Mathematical Council. Further, our group was commissioned by the Executive's Enterprise Department to conduct the international *Relevance of Science Education (ROSE)* survey in Scotland, yielding a considerable body of data on pupil interests and opinions. This can very usefully inform strategies to review new approaches to school education, and further work is also being done with the Scottish Science Centres Network on how their strategies could respond.

This Industry Project attempts to bring the views and priorities of employers into our overall framework, so that these can be accorded full recognition in curriculum review planning.

All of the above work is designed to feed into a major curriculum analysis and modelling exercise. This is STEM-ED Scotland's *'Green Field Curriculum'* project, to be run with Scottish Executive funding for 3 years from April 2007 (Sec 6). This aims to develop new models for the school curriculum across science, technology, engineering and mathematics disciplines

i. coherently re-thought from 21st century perspectives
ii. rooted in communicating the core ideas and principles of the modern disciplines
iii. attractive for teachers to teach and for learners to learn
iv. geared to provide for a future adult population literate in science and technology matters
v. building appropriate base skills, at all levels, for recruits to careers in the knowledge-led economy
vi. designed to yield keen and well prepared applicants for STEM subjects in universities

[1] *Science Education for the Future: Liberate Teachers and Engage Pupils*, 2005, available at http://www.gla.ac.uk/stem

1.2 This industry project: original work and review of evidence

The project was designed to review and to integrate the views of Scottish Employers in STEM-related businesses, on the suitability of the school education of applicants to their workplaces, with an aim then to feed these as effectively as possible into discussions of school curriculum review. We felt it important to carry out our own study with these aims in mind and to conduct a fair proportion of this in a discursive interview mode. We then complemented this information through a review of conclusions reached from a large number of other studies of industry.

A pilot questionnaire was designed, and refined after a short initial trial. Face-to-face and telephone interviews were then carried out with over 50 companies. 250 postal questionnaires were also sent out although the proportion of these returned was only around 10%. The survey was designed to explore employers' opinions of the skills, knowledge and attitudes of school leavers entering the workplace to take up either apprenticeships or work as process operators or as skill-seekers.

The businesses surveyed are well spread geographically and include a mix of both large and smaller companies. A small number of training centres, professional bodies and colleges were also approached. The range of companies covered included representation from the chemical, pharmaceutical & biotech industries; oil & gas, electricity & water; electrical, electronic, optoelectronic, mechanical & civil engineering, and from the food & drink industry. A full list is given in the Appendix. Although the survey was designed to collate industry perceptions of school leavers, as work progressed several participants mentioned the difficulty of obtaining suitably qualified graduate engineers and so in the later stages we included questions about this. A more detailed account of the survey and responses is given in Sec 2 of this Report.
We then examined a broad range of reports and reviews relevant to industry in Scotland (over 50), as described fully in Sec 3. Our intention is to use all of this information alongside evidence we have already analysed from universities, teacher organisations and pupils, which we briefly summarise in Sec 4. In Sec 5 we provide a short review of the current school curriculum structure, the subjects studied and issues of performance and progression. Lastly, in Sec 6, we outline the proposed approach to a major 'Green Field' analysis of possible future models for the STEM curriculum, for which we have been promised Scottish Executive funding.

1.3 Conclusions of the study

Priorities: 1st Attitudes, 2nd Skills, 3rd Knowledge

The challenge faced by employers is to grow a skilled, committed and adaptive workforce. It was clear from the great majority of interviews that the single most important obstacle in the way of achieving this lay in the attitudes of many young people to the world of work. Nurturing positive and proactive attitudes through education was an aim to which they would attach great priority. Core and transferable skills come next in priority: these are essential too, and the better they can be developed through education the better the contribution that can be made in employment. Knowledge matters too, but very few participants gave great emphasis to specific detail: possessing a broader understanding of relevant subject areas, and being willing and able to work with, see the relevance of, and analyse information was more important.

Different nuances in concerns about recruits at different levels

Technology based companies in general recruit from education at three different levels, at operator / skill-seeker level, for modern apprenticeships and at graduate level. At the basic level there is widespread concern over the difficulty of finding appropriately interested staff, willing or able to engage constructively with colleagues or contribute positively to the productive success of the company. Companies are in general positive about their modern apprentices once in place and fully engaged in training, but most feel that they are selecting these recruits from less well performing school leavers than in the past, due to the very large numbers being encouraged to progress from school to university: companies point out that modern apprentices can access very attractive career opportunities. With graduates, concerns are again first with attitudes, to do with general readiness to engage appropriately in their specific role and an appreciation of the broader work context. Skills are also an issue, notably in interpersonal communication and team working, but also in transferring skills developed at university to their work role.

Overall concerns about attitudes, skills and knowledge

Attitudes identified as important were

- enthusiasm and commitment
- good work ethic
- confidence and outgoing nature
- persistence and perseverance
- creative approach - seeking solutions
- independence and initiative
- take responsibility for own actions
- respect

Skills stressed were

- numeracy
- literacy
- oral communication
- written communication
- problem solving
- team working
- planning & organisation skills
- practical / technical skills

Specific knowledge highlighted as important included

- basic mathematics
- quantities and measurement
- some understanding of engineering and of the impact of science both present and future
- some breadth of basic knowledge
- understanding and the ability to apply knowledge in new contexts

Other issues related to advice and awareness raising

- more appropriate advice is needed on STEM careers, from an early stage
- more pupils should be encouraged to take STEM subjects
- awareness needs to be raised of the role engineering and science plays in our lives
- effort is needed to improve the image of engineers and scientists
- concern that schools seem to encourage direct progression to HE rather than to work

The brief summaries above are substantially amplified and extended in Sec 2 of this Report.

Additional perspectives from our review of other relevant reports

Our extensive review of a wide range of other reports of relevance to industry in Scotland and in the wider UK generally reinforces the messages from our own interviews. It also

- adds a broader economic perspective, and gives quantitative analyses of a number of key issues such as identified skills gaps
- emphasises that improving skills is important not only for the economy and for individuals, offering a way out of poverty and enhancing social mobility
- highlights the significance of the UK 'NEET' problem (the large number of young people 'not in education, employment or training')
- reinforces the need to raise the status of the vocational route
- raises concerns about insufficient numbers of engineers and physical scientists being produced – bioscientists, food scientists and environmental health professionals included

- draws attention to the significance that attracting more women into traditionally male-dominated roles, will both widen the talent pool and also encourage diversity and may potentially enhance creativity
- notes that little progress has been achieved since the Robert's Review raised several of these issues in 2002

Much more detail, and a review of quantitative evidence is given in Sec 3 below

1.4 Views of other stakeholders

Previous work carried out across all of Scotland's universities echoes most of the issues raised in this current exercise. Concerns were expressed at the declining trends in numbers pursuing individual STEM subjects both in schools and universities. Attitudes to work and study were thought of crucial importance, alongside well-developed key scientific skills. The universities also would give priority to improving mathematical skills and confidence. They agreed that engineering needs a much enhanced profile in schooling. In general the views of the universities were more specific and great concern was felt about the negative consequences of inappropriate models of assessment.

There are few if any areas of disagreement between the two studies, though the following identifies some issues more emphasised by one group or the other

given more emphasis by industry

- cater for all school leaver groups
- technical skills
- team working
- careers advice
- engineering
- work experience

given more emphasis by universities

- understand major principles
- relevant 'issues'
- role of assessment
- mathematics
- logical argument
- computing science

Pupils' views have also been studied in our ROSE survey (on the 'Relevance of Science Education'). S3 pupils were questioned about their interest or otherwise in numerous 'science' topics and on their attitudes to science and technology issues. More than 2750 responses were received from 92 schools in 31 of the 32 Local Authorities and a preliminary analysis of results completed. In very broad terms the results show

- views are net negative overall, and generally in line with other developed countries
- girls are somewhat more negative about science, and especially about technology
- differences by gender are dwarfed by stronger variations between pupils taking different science courses, with lower achieving groups the most negative
- the 'number of books in their home', as estimated by pupils has a very strong correlation with opinions: those from book-reading homes being much more interested and engaged
- there is much scepticism about the benefits and trust-worthiness of science
- science in school fails to engage the less able pupils and is rated poorly overall relative to other subjects
- a majority disagree that school science has made them think more critically
- there are strong indications of types of science and technology topics that, if selected, could better engage pupils and there is evidence to suggest optimum ways to approach important issues

The evidence of pupil views highlights both the challenge and the opportunities of curriculum reform. A more detailed summary is given in Sec 4, for both of the above studies.

1.5 The current educational picture in Scotland

In Sec 5 we present a review of current circumstances, covering

- the range of qualifications and subjects taken in schools, highlighting progression issues and the declining uptakes of science subjects, and the particularly parlous position with Technological Studies
- analyses of relative difficulty and of other factors governing subject popularity
- Scotland's standing in international comparisons
- information on progression beyond school

These various reviews throw further light on the scope for curriculum reform. Fortunately, reform is indeed being actively promoted. The Scottish Executive's paper *A Curriculum for Excellence* provides a vision and a framework for reform that seems almost perfectly suited to addressing the issues for STEM subjects raised in this Report. *ACfE* sets the following key purposes and principles for a new coherent approach to the curriculum from age 3 to 18.

The purposes of the curriculum are: — to enable all young people to become ■ successful learners ■ confident individuals ■ responsible citizens ■ effective contributors	The principles for curriculum design are identified as ■ challenges and enjoyment ■ breadth ■ progression ■ depth ■ personalisation and choice ■ coherence ■ relevance

1.6 Taking things forward

All of our work to date, on this and on previous projects, has been carried out with the aim of informing school curriculum reform in Scotland.

There is significant work ongoing:

i. on "de-cluttering" curriculum guidelines and proposing new learning outcomes for the 3 – 15 age range, led by the Scottish Executive Education Department with Learning & Teaching Scotland: this is working on seven subject groupings of which three relate most directly to our concerns, namely Sciences, Mathematics and Technologies
ii. on updating National Qualifications (one year single subject courses designed for S5 & S6 stages, at Intermediate, Higher and Advanced Higher levels), led by the Scottish Qualifications Agency

Both of these activities are being pursued in the context of the agenda established by the *ACfE* Report. They focus on promoting a process of change from current arrangements.

We are highly supportive of this work, and we have communicated our past findings to those concerned, and will continue to do so, most particularly with the outcomes of this industry study.

The university, industry, government and teacher stakeholder groups we have worked with all recognise the extreme significance of STEM subject education to the future economic and social success of Scotland, and we would wish to be able to promote ideas, and debate, about curriculum models that would be truly world-leading. School subject curricula, across the whole world, have in general evolved incrementally and separately from one another for the last century or so. In the meantime the world has changed almost beyond recognition: activities at the forefront of science and technology routinely cross traditional subject boundaries and the key significance is recognised of broader understanding and high level transferable skills.

In Sec 6 we describe our proposal for a fundamental study aiming to draw up coherent "Green Field" models for a curriculum across the STEM subjects, developed from first principles and from a 21st Century perspective. This would be founded on the collective insights of all of the major stakeholder groups.

The Scottish Executive has agreed to fund this for three years starting in April 2007, subject to some further discussion on the details.

2. REVIEW OF RESPONSES TO THE STEM-ED INDUSTRY SURVEY

The purpose of this project is to articulate as far as possible a coherent set of views from across the range of employers active in STEM-related fields in Scotland, with the intention subsequently to feed these as effectively as possible into discussions of school curriculum review. We felt it important to carry out our own survey with these aims in mind and to conduct a fair proportion of this in a discursive interview mode. In Sec 3 below we further assess and complement this information through a review of conclusions reached from a variety of other industry studies.

A draft questionnaire was piloted with 6 companies, and then refined for use in all other interviews. In its final form it was in six sections, with 3-5 questions each.

Telephone interviews were been carried out with over 50 companies in diverse STEM-related sectors. In four of these companies we conducted 'Triple Decker' interviews of individuals in senior management, HR/training and engineering roles. This did not seem to reveal characteristic differences in views and hence, more generally, only one individual per company was interviewed. Interviews were also held with representatives of a small number of training organisations, colleges and professional bodies.

In addition to personal interviews a postal survey was also undertaken. A pilot run of 21 sent to named individuals was fairly successful, with a 33% return. However a larger subsequent batch of 240 forms produced less than a 10% return rate, perhaps because no previous telephone contact had been made and in some instances the surveys was not sent to a named individual.

The companies interviewed represent the pharmaceutical, chemical, utility, electronic, oil, bioscience, engineering, electrical, and food and drink sectors in addition to the apprentice training organisations, FE colleges and professional bodies. The returns cover a good geographical spread from Caithness in the north to the Scottish Borders in the south, and from Dundee and Aberdeen in the east to the Glasgow and Ayrshire areas in the west. A full list is given in the Appendix.

Responses to each of the six sections of the survey are reviewed below.

2.1 Section 1: Recruiting and selecting applicants

Two questions were asked in this section:

1. *What difficulties, if any, have you experienced in the last five years attracting enough young people to work for you?*
2. *Have you had any difficulties in the last five years recruiting enough young people with the right skills for work?*

Apprentices

Most companies received a large number of applications for apprenticeships. For example this year Scottish Power received over 1400 applications for 36 apprenticeships. Only 12 companies said that they had any difficulty attracting applicants to take up apprenticeships and these were mainly from smaller engineering firms in the more rural areas either in the north–east, the borders or the Highlands. BP Dyce also experienced problems which they attributed to the perception that the oil industry was not regarded as attractive and also to the low local

unemployment rate. One company reported difficulties attracting women and ethnic minority applicants but they had no problems attracting white males.
Three distinct strands of company opinions were expressed

- companies having difficulty finding enough suitably qualified applicants in spite of the large number of applicants: it was believed that companies were not getting the same pick of pupils as previously and more would now prefer to go to university, leaving only pupils with poorer qualifications to apply
- others commenting that recruitment of MAs is not difficult as there are not as many being trained as there were 15 years ago and so there is competition for the places available
- companies commenting that the problem was not that there were insufficient people applying for apprenticeships but that insufficient apprenticeships were being offered as companies could not afford to train as many as they wanted and it was thought that there may be a shortage of qualified technician engineers in Scotland due to this in the years to come.

Rolls Royce at East Kilbride and the UKAEA at Dounreay were two of only three of the companies interviewed that said they had experienced no problems recruiting or selecting and were always happy with the people selected. They attributed this to their good reputation as an employer and to the job prospects they offered. The third company attributed their lack of difficulty to the closure of a large electronics company nearby and hence the ready availability of already-trained labour.

Companies generally start apprentices at 16 straight from school but most are now much more flexible and will also recruit apprentices in their twenties. There is a trend for pupils to stay on at school longer and complete six years of secondary school. It is felt that schools encourage this and also promote Higher education as the best route to a career. Some companies prefer to take entrants with better qualifications and also aged 17 as they think that this has given them an additional year to mature as well as increasing their knowledge and skills. These companies also think that it is only pupils who do not like school who now leave at 16 and they will tend not to be good candidates for an apprenticeship. Others take the opposite view and prefer 16 year olds who can be encouraged into the work ethic.

The larger companies have rigorous selection processes including tests in numeracy, written communication and aptitude in addition to an interview. The new starts then receive training where they are carefully supervised and shown what is expected of them. These employers report few problems with recruits although some remarked that a few school leavers did not seem to appreciate that they had to turn up on time and every day.

Process operators

A different picture emerges when companies seek to recruit school leavers for assembly line and process operations or if they are engaged as Skill-seekers, either directly employed by the company or on training schemes where they are given work placements. They are in many cases found to be very different from apprentices. Many have poor attitudes and many do not complete training, even where they would have had the opportunity after two years to continue with training as an apprentice.

In some areas where unemployment is low it is difficult to recruit the quality of worker required. Not everyone who turns up for interview actually wants a job and for many who are recruited their attitude can leave a lot to be desired. In many areas of Scotland there were no shortage of applicants but in many cases it was still found difficult to recruit workers with the correct skills and attitudes.

Our attention was drawn to a report for the electronics industry[2] which describes the direct labour supply as "tight" with quality having fallen markedly over the last three years. This was attributed to at least two factors, poor educational standards and increasing job opportunities in other service based sectors (retail and call centres). The attitude of direct labour to employment opportunities in the electronics sector was considered to be poor. This is not a problem unique to Scotland, having been reported in the Netherlands and other Western European states and also in Singapore.

Several smaller and medium size companies indicated that they had a stable workforce and had not recruited for several years either from school or elsewhere and many more were not currently taking on apprentices. Some of these acknowledged that their workforce was ageing and that they would have problems in the years to come if they did not start training replacement workers.

2.2 Section 2: Attitudes

Four questions were asked in this section:

1. *In which way do you think work attitudes of school leavers have changed in the last five years?*
2. *What impact has this change had on your business?*
3. *Which attitudes do you rate most highly?*
4. *How could work attitudes of school leavers be improved/ further improved?*

Generally employers have a large number of applicants for apprenticeships and so by careful choice they can select suitable candidates. This means that in general there are no huge problems with attitude. Also while in the workplace they are well supervised and "do not get away with anything". Problems may occur while they are on day release at college where they do not seem to be so closely supervised.

Several respondents commented that pupils from school are not as independent as they once were and expect more to be done for them. In illustration of the extent of this problem, one participant described trainees, when asked to cut material into lengths, expecting to be handed a saw rather than to find one from its place of storage. It was recognised that such attitudes may derive as much from home as from school experience, with children left to their own initiative less often than in previous generations. However, it was felt that schools should attempt to nurture initiative.

Employers who had difficulty recruiting suitable applicants tended to make more comments on the attitudes of the school leavers who were working for them. Varied examples were quoted including: lack of enthusiasm for physical work, over-focus on 'rights as workers', poor attendance, lack of self-discipline, a "why bother attitude", expectations exceeding abilities, and little respect for skilled staff.

Skill-seekers and process operators are different and many problems were reported for this group of school leavers. Many turn up for interview not wanting a job and others when offered one do not subsequently turn up. Punctuality and attendance are often not good. They often lack interest and are not motivated even where prospects for advancement are promised if they perform well. They have a short attention span, are troublesome and often simply do not want to work. One employer when asked about the impact of skill-seekers on his business responded

[2] Review of High Value Electronics Manufacturing in Scotland, O'Herlihy and Co. Ltd, May 2005.

that people actually needed to attend to keep up production. Industry needs people who are keen to work and prepared to work hard. In addition skill-seekers tended to have poorly developed social skills.

Another employer who trains skill-seekers described one extreme experience. The problem of non-attendance was such that he organised a bus to pick trainees up from their homes. This was not very successful, with sometimes less than half boarding the bus. Eventually the minibus driver refused to continue as the vehicle was being vandalised by the skill-seekers.

It was noted that many of the young people employed at this level were from difficult backgrounds and had had a very troubled upbringing. However it was stressed that many skill-seekers, and also many MAs, with less than an ideal upbringing had nonetheless developed very successfully. Employers were at pains to make clear that they did not blame schools for these social failures.

Engineering companies must continually strive to remain competitive. Reducing labour costs has increased requirements for multi-skilling of a smaller total labour force. It has also meant that it is important for new workers to be productive as quickly as possible, and hence to be self-confident, to show initiative and to take responsibility at an earlier stage than perhaps previously. This is probably more difficult for a young person now than previously as our social culture has probably evolved in the opposite direction, with young people now much more heavily supervised and "spoon-fed" than in the past.

Many employers believe that better discipline in schools should be a top priority. It was suggested that schools giving pupils too much study leave set a bad example, encouraging an impression that school attendance did not really matter. One employer indicated that he always checked a pupil's attendance record before offering employment.

Hope was expressed that the new Skills for Work schemes beginning to be offered in schools might improve the situation and prepare young folk better in things such as time keeping, health and safety, following instructions and cooperating with others.

In some sectors, where there was a large demand for general workers, employers had found that workers from Eastern Europe were keener and had a better attitude to work than native Scots. Unless more pupils are motivated to work and study at school the prospects for young unskilled Scots were seen as becoming increasingly bleak. It was also reported that many young people leaving school are not prepared to start in manual jobs even when there are good prospects for promotion: they seem to expect to be able to start further up the ladder.

Some employers felt that a lack of positive attitudes and self-confidence was particularly significant. (This comment seemed most prevalent among employers in the North East and the Highlands, although perhaps this is a coincidence rather than a regional characteristic.) When accompanied by a lack of communication skills problems in the workplace are further exacerbated. Two respondents commented that this was in contrast to the situation in Ireland, where school leavers and workers more generally were reported to be much more self-confident, with excellent communication skills. A more optimistic outlook and a "can do attitude" of the Irish had caused one MD to contemplate moving his factory from Scotland to Ireland.

It was felt that the ethos in some secondary schools needed to change to foster self-confidence, enthusiasm and creativity. Creativity appeared in many cases to be stifled by teachers' desire to tell pupils what they should do. This was illustrated by an account of a factory visit where school pupils had been asked to design packaging for a particular item having been given paper and scissors etc. The pupils had been encouraged to look at as many different ways as possible and to come up with something different. When the organiser visited one group she found the teacher instructing the pupils in detail how to make a rectangular box, and the teacher continued to do this in spite of pleas to let the children think for themselves. Criticism was also made of some of the initiatives in schools to develop an enterprise culture, coupled with a wish that Scottish Enterprise "*would get away from the idea that enterprise is about setting up one-man businesses".*

Scotland aims to grow its economy through the skills of its workforce but the above discussion highlights the importance of individual attitudes. There is no point in possessing high-level skills if attitudes are inappropriate. Employers want a motivated, enthusiastic workforce with "a good work ethic", confident in their own abilities, willing to learn, ready to show initiative, and to take responsibility for their own actions. The following are seen as priorities for schools:

- To promote positive discipline
- to nurture a work ethic and respect for others (recognised as a wider issue, not attributable to the schools alone, strongly influenced by parental practices and societal attitudes)
- to nurture powers of persistence and perseverance
- to encourage pupils to be more confident and outgoing, volunteering to undertake tasks and ready to venture ideas
- to give pupils more freedom to think for themselves and to take more responsibility for their own learning
- to encourage creativity

2.3 Section 3: Core skills and knowledge base

Five questions were asked in this section:

1. *In what ways have new entrants' core skills changed over the last five years?*
2. *Which core skill do you rate as most important?*
3. *What changes have you seen in school leavers' depth of knowledge and understanding over the last 5 years?*
4. *How has this impacted on your business?*
5. *How could core skills be improved in schools?*

It should be stressed that many employers were happy with the school leavers they had recruited directly from school and that many young people who leave school to enter the workplace fit in very well. However, the number of pupils who enter work direct from school is falling and many who do so have very few if any qualifications. The widening gap between the high achievers at school and those who under-perform seriously concerns employers.

The overall impression is that, in spite of the intentions of the Higher Still reforms, core skills have not improved among school leavers. One respondent regarded Higher Still as a missed opportunity and hoped that the current review would involve real change rather than merely "tinkering round the edges". Many think that standards at school are not as high as previously and an opinion was expressed that a Higher now was equivalent to an O-grade taken 15 years ago. Whether this apparent decline in standards is due to a real drop or is due to the rise in numbers of pupils progressing to university leaving a less able group of pupils to apply for apprenticeships is not clear. Employers generally have the impression that schools do not encourage their pupils to apply for jobs in industry. Several commented that in spite of good maths qualifications many are not competent in basic numeracy and simple mathematical techniques. A potential employee may have good paper qualifications but be unable to apply the knowledge. Some employers would like to see a more problem-based approach used in schools to help this situation.

Over 60% of employers were not happy with the mathematical ability of many new entrants. The inability to use fractions and units was highlighted. Schools have taught only metric units for over 20 years whilst in the outside world imperial units are still widely used. If a pupil is asked their height or weight they usually reply in feet and inches or in stones and pounds, but many will not know how many inches are in a foot or how many pounds in a stone. Industry thinks that schools should give experience of different sets of units and of calculating conversions. Appreciation of scale is also important. Even at the most basic level, some recruits have difficulty relating lengths, commonly expressed in mm in industry, to cm values experienced through school.

Literacy was next in priority for improvement with over 50% commenting on this. Written work tended not to be good with many unable to communicate what they wanted to say on paper. Spelling and grammar were also commented on. Oral communication was seen as a real problem area with many employers commenting on how inarticulate many young people were. One employer argued that the aims of the Smart Successful Scotland Strategy would critically depend on achieving enhanced basic skills in communication, literacy and numeracy for a large proportion of our young people.

Problem solving, teamwork and practical skills were also commented on, though some thought these could satisfactorily be developed on the job. Many commented that pupils did not seem as capable to think for themselves as previously and that this was perhaps due to a "spoon-feeding" approach at school. It was felt that schools were too exam driven and sometimes encouraged softer and "sexy" subjects at the expense of the basics. To help pupils become more independent some advocated taking a problem solving approach in some areas. Some trainers commented that apprentices took longer to train than previously, at a business and competitive cost.

Many in industry view with concern the decline in popularity of science and mathematics in our schools. This will result in a further decline in the number of graduates taking degrees in science and engineering. The CBI view[3] was shared that this will leave the Scottish economy short of engineering, science and technology knowledge and skills that will be needed. Such a shortfall will damage the prospects of some of Scotland's most important industries, such as in electronics, energy, life sciences, aerospace and defence.

Our direct discussion with the Scottish CBI emphasised their published conclusion that schools are failing to engage meaningfully with too many young people, leaving them far short of being "work ready", often with few or no qualifications, too little to show for the years spent in the classroom. This has the consequence that businesses have to invest a large part of their training budget in remedial education rather than on sharpening their competitive edge. The CBI hopes that the *ACfE* review will provide an opportunity for radical change. It is not easy to predict what specific training and education needs will be required for the future but the following generic skills are vital:

- literacy and numeracy
- communicating and team working
- problem solving

[3] The Scottish Economy; The Priority of Priorities CBI 2006 (further reviewed in Sec 3.6.4 below)

- adaptability and flexibility
- awareness and understanding of enterprise

Employers see the following as priorities for schools

- to improve standards of numeracy and literacy throughout the school years for all pupils and especially for the group of pupils who are currently underachieving
- to ensure that pupils have a better understanding of basic mathematical techniques and greater facility in handling quantities and measurement
- to convey a better understanding of units of measurement and inter-conversion of these
- to give pupils more responsibility for their own learning and more involvement in team building and project work
- to encourage an increase in uptake of mathematics and the sciences, perhaps by changing how these subjects are taught

2.4 Section 4: Competency

Three questions were asked in this section:

1. *What changes have you observed in the way recent recruits are able to apply their knowledge to their jobs?*
2. *What differences, if any, have you seen in the competency levels of recruits in engineering/ technical jobs compared with five years ago and also when compared with non-technical recruits?*
3. *What changes in the school education system would improve the competency of young people in the world of work?*

Not everyone had noticed a difference in the competency level of new starts and some thought that there were "just good years and bad years". Many thought that practical skills were in decline and that the ability to produce and understand technical drawings had been lost. On a general level it was thought that pupils should have a better understanding of what they had been taught and that mathematical ability should be progressively built up throughout the years of school integrating mathematics with other subjects.

Schools were seen as too assessment driven and being interested only in their results and concentrating on sending pupils to university. Too little was done to prepare pupils for the world of work and the teaching of life skills seemed largely ignored or at any rate ineffective. Pupils were not encouraged to consider apprenticeships as a first career choice and many had no knowledge of the opportunities available. In many cases work experience does not provide a meaningful introduction to technical work, as there are restrictions on what a 14 year old is allowed to do in a factory. It is hoped that the Skills for Work programme will help this situation and that well qualified pupils will be encouraged to take this route.

Some regretted the decline in the numbers taking Technological Studies at school and felt that there was a problem with investment in the subject and also in the numbers of teachers available to teach it. Others were quite happy with the other alternative subjects on offer under *Craft & Design* and *Product Design*.

Welcoming the move to incorporate *Science for Citizenship* in the school curriculum it was thought important that pupils should also understand what engineering and technology have contributed in the past and their roles in our future. There was concern that "science" can be too narrowly interpreted and what was needed was *Science, Engineering and Technology for Public Understanding.*

Employers see the following as priorities for schools:

- to focus on giving pupils a better understanding of the basic principles of a subject and an ability to apply this knowledge.
- to encourage uptake of the new Skills for Work courses and design these to help improve pupils' employability
- to revisit the whole issue of what pupils' experience of engineering in schools needs to be, to convey the scope of engineering and technology and involve a mix of theory and practical
- to incorporate engineering and technology in courses on *Science for Citizenship*

2.5 Section 5: Schools careers advice

Three questions were asked here:

1. *What impact has the Careers Advice at your local schools had on recruitment over the last 5 years?*
2. *What involvement does your company have in careers advice and activities in your local schools?*
3. *What should schools be doing to attract and prepare pupils for entry to STEM related careers?*

The impression of employers is that schools encourage pupils to stay on as long as possible at school and then expect them to progress to higher or further education. Pupils are not encouraged to leave school at 16 to take up an apprenticeship and in general engineering is not promoted as a career choice at any level. The brightest appear to be encouraged to study medicine or law rather than science and engineering. It is felt that teachers are not aware of the huge choice of careers in engineering and science and that the predominant image of the chemical and engineering industries is that they are unattractive, dirty and polluting, rather than that they are leading innovation and wealth creation. The press is partly blamed for this bad image as only disasters and redundancies seem to be reported. Employers generally felt the same way about careers advice for their own sector. Those in the Food and Drink industry commented that lack of encouragement to pupils to pursue a career in their sector had resulted in a serious decline in the number of college and university courses offered.

Career advice should be given before subject choices have to be made, as by the time pupils have taken Standard Grades they may discover too late that for a given career they have taken the wrong range of subjects. One employer said that they asked for a S-grade in physics for entry to their apprenticeship scheme, but they found that in their local school many pupils were encouraged to take biology instead as that was regarded as an easier subject in which to get a good grade. Parents are believed to have a crucial influence on career choices and it was thought that there was a need to educate them in the careers available in engineering and technology.

Most companies had extensive involvement with careers advice and activities in local schools and thought that they were doing all they could to help, although two companies interviewed had now outsourced their human resources departments and as a result no longer had any links with local schools. This was a matter of regret to them and they worried about the impact this would have on local recruitment.

For the third question, apart from making pupils more aware of the career opportunities available, it was thought that there should perhaps be a radical rethink of "engineering" courses at school and to tailor these courses for the different ranges of pupil. These courses should give a better idea of the range of engineering and technology and also a better mix of practical and theory than at present. It was also thought that more meaningful and perhaps longer work placements would help.

Employers wish to see

- improved career advice for engineering careers
- careers advice to be given before school options have to be decided
- consideration of delaying subject specialisation until a later stage of schooling
- perhaps embedding what careers are available into the actual school curriculum
- encouragement of more work placements (where employers recognise that they have a role to play)

2.6 Section 6: Industry awareness and support

Three questions were asked here:

1. *What activities has your company been involved in within the last five years actively to recruit in local schools and colleges?*
2. *Is your current level of involvement likely to increase, decrease or remain the same in the near future?*
3. *What support would encourage you to become more involved?*

Most companies were actively involved in recruitment in local schools and communities. Many are involved in careers fairs, work experience; *Make It In Scotland*, the *Science & Engineering Ambassador Scheme*, enterprise initiatives, mentoring, WISE etc. Others invite subject and careers teachers to their factory and a few have said that they would welcome the opportunity to go to schools to talk about engineering or science or food technology, etc., but noted that this had not been encouraged by local schools.

Asked of plans to increase or decrease their current involvement most said that it would probably remain the same. Activity would only increase if there was a sudden need to train more apprentices and if the company planned to expand its operations. Additional financial support from government could encourage companies to become more involved but most felt that they were already doing enough. One company had stopped taking work experience pupils as they had experienced problems with them and felt that they were being used as a dumping ground for disorderly pupils.

2.7 Engineering Graduates

Although the focus of this project is on the employability of school leavers, graduate employment was a subject mentioned by many of those interviewed. Many companies had problems recruiting suitable graduates, particularly in engineering and food science. Employers wanted graduate engineers with the particular range of skills their industry required and many wanted some kind of prior experience. They felt that many graduates had no experience to offer unless they had done a degree which offered a year's work placement and would encourage undergraduates to try to find suitable work during the summer vacations so that they have some experience to augment their CV. This was believed to make graduates much more employable. Many are also concerned about the decline in numbers of students actually taking engineering degrees. In Food Science there is a demand for graduates but not many college or university places are offered, as the subject does not seem to be popular with students. Some companies go overseas to get graduates at present although they are in discussion with colleges and universities about the feasibility of some new courses.

3. REVIEW OF OTHER EVIDENCE ON INDUSTRY NEEDS

We have reviewed a wide range of other sources in order further to illuminate the context of our work, and to provide fuller relevant information. We review each of these in the subsections below.

3.1 Skills needs: a UK perspective

The UK's employment rate, at 75%, is one of the highest among the G8 countries. However, there are still large numbers of people who find it difficult to find work and many of these have low or no skills. 2.2 million of the 7.8 million economically inactive in the UK working age population have no qualifications at all and almost one half, 3.7 million people, lack a Level 2 qualification. According to the International Labour Organisation (ILO) definition around 1.7 million people are unemployed. Again for this smaller group, almost one half (750,000) has less than a Level 2 qualification, including around 300,000 who have no qualifications at all. Around one quarter of disabled people have no qualifications and 50 per cent of the disabled with no qualifications are out of work.

As the global economy changes, the employment opportunities of those lacking skills will fall still further. The millions of adults lacking functional literacy and numeracy skills risk becoming increasingly cut off from the labour market. As the Government sees work as the best route out of poverty, tackling basic skills should lead to a reduction in child poverty.
Social mobility in the UK is low and has fallen in recent times so many people moving into work become trapped in low paid, unskilled work. Those in low paid work tend to be those with low or no qualifications. Over one quarter of all employees, almost 7 million people, have less than a Level 2 qualification and almost 2 million employees have no qualifications at all. The best way to improve social mobility in the UK is to ensure that everyone has the chance to increase and upgrade his or her skills.

3.2 Scotland's labour market

There are more people in the labour market in Scotland than ever before but, according to Futureskills Scotland[4], one fifth (621,000) of the working age population in 2005 (excluding students) were jobless and of these nearly half (281,000) wanted to work. 11% did not want to work and 123,000 were unemployed on the official definition. 36,000 people aged 16-19 were classed as NEETs (not in education, employment or training). From 1998-2004 there was a fall in the numbers employed in the manufacturing sector from 330,000 to 250,000, the mirror image of a rise in the numbers employed in health and social work from 250,000 to 330.000. A further decline of around 10% in engineering and manufacturing employment totals is predicted between 2004 and 2009. However as the working population is ageing there will be large numbers retiring leaving opportunities for young workers in all sectors of industry even where the numbers employed are declining.

Skill shortages were described as relatively uncommon in Scotland, although one in five workplaces reported skill gaps. These skill gaps were often of short duration due to the employee gaining experience or receiving training. Skills gaps were reported as most common in work roles which require lower levels of skills. The skills that employers most often thought as

[4] Futureskills Scotland (Scottish Labour Market 2006) at
http://www.futureskillsscotland.org.uk/site/home/Reports/NationalReports/Repor…

lacking were softer core skills, namely planning & organisation (54%), customer handling skills (52%), problem solving skills (50%), team working skills (49%) and oral communication skills (45%).

The report concludes that attracting skilled staff is not one of the major challenges for Scottish employers and they predict that there will be opportunities in all sectors and occupations as existing workers retire. They also predict an increase in the number of jobs, which will require higher level skills.

3.3 Scotland's STEM industries by Scottish Enterprise sectors

Scottish Enterprise[5] has reviewed industry clustered within the following sectors of relevance to STEM occupations. Some companies will be represented in more than one of the different sectors reviewed below and so statistics such as total headcounts should not be totalled across sectors.

Aerospace
The UK has the world's largest aerospace industry outside the USA. Scotland has approximately 10% of the UK aerospace industry, with 150 companies employing over 30,000 people if the defence equipment sector is also included. The three parts to the industry are – maintenance, repair and overhaul (MRO); manufacture and design and avionics. The major players in Scotland include BAE Systems, Rolls-Royce, Raytheon, Thales, GE-Caledonian, British Airways Maintenance Glasgow, Honeywell, The Goodrich Corporation, Woodward Governor, MB Aerospace, WL Gore, Teledyne, Wood Group Aero, Selex S&AS and Spirit AeroSystems.

Electronics
More than 1000 companies involved in designing, developing, and supplying electronic products and/or services are located in Scotland. Over 45,000 people are employed directly and a further 29,000 indirectly. Electronics accounts for 12 per cent of Scotland's total manufacturing employment and for more than half of Scottish exports. Scotland makes 7% of the world's PCs and the biggest exports from this sector are PCs and printers.
Microelectronics
2,300 are employed in semiconductor fabrication, 1,000 in electronics design and a further 1,800 in supply and support industries.

Optoelectronics
4,200 are employed, turnover is £800M, and 65% of production is exported. Scotland accounts for 34% of UK Government spend in optoelectronics research (with only 8% of the UK's population).

Engineering Manufacturing Industry
The industry employs about 128,000 people, three quarters of whom are male. This figure accounts for about half of all manufacturing jobs. This sector has a rather different profile than other industries as there is a much higher proportion of people employed as skilled tradesmen and also as process and machine operatives. Compared to other sectors there are a larger number of skill shortages and gaps. When a vacancy occurs in the sector that is hard to fill, this is usually attributed to an insufficient number of applicants. Employers are concerned that not enough people are interested in doing this type of work and, for those that are, they

[5] Information can be obtained from the Scottish Enterprise web site at http://www.scottish-enterprise.com/

face competition from other employers. In this sector skills gaps are more likely to be in technical and practical skills rather than the softer skills, although team working, communications, planning and organising and problem solving skills were also thought to be important.

Science Engineering and Technology sector

This sector employs 97,000, and around one third are process, plant and machine operatives. Where skills gaps occur employers are concerned with both weaknesses in the soft skills and the technical and practical skills. They are more likely to have recruited employees from school than most other sectors. As in other sectors they highlight soft skills when relating to a skills gap in their employees. These skills include planning & organising, team working, problem solving and oral communication skills as well as technical and practical skills.

Engineering Construction industry

This covers 151,000 employees one third of who are professional level staff. One of their priorities is to recruit appropriately qualified staff. Where skills gaps occur, like other engineering sectors, employers criticise weaknesses in technical and practical skills. Attracting skilled staff was the biggest challenge facing employers in this industry. A greater proportion of vacancies in this sector were hard to fill and these vacancies arose because of skill shortages and gaps.

The Construction Industry

The construction industry is vitally important to the Scottish Economy and employs 250,000 people. It represents around 10 per cent of Scotland's GDP and is worth approximately £10 billion to our economy. This industry regards one of its main challenges as attracting appropriately skilled staff. Compared to other sectors they had a larger proportion of vacancies that are hard to fill and these vacancies were due to skill shortages. They also report gaps in technical and practical skills as their reason for difficulty in recruitment. The industry has expressed concern about the decline in the numbers applying to study civil engineering at university.

Chemicals, Nuclear, Oil and Gas, Petroleum and Polymers[6]

There are 59,000 employees in this sector with one quarter employed as process plant and machine operatives and a fifth in professional occupations. Recruiting people with the correct skills was not one of this sector's main challenges but they were most likely of all the sectors to recruit university graduates. They have more hard-to-fill vacancies that are due to skill shortages than some other sectors. When skill gaps occur they tend to be in the soft skills such as team working, planning & organising, and problem solving although they also cite technical and practical skills as well.

The Sector Skills Council Cogent[7] has reported that recruitment needs are changing due to the ageing workforce. Many companies will be recruiting young people and graduates over the next decade, and the number of technician apprentices will be increased. Some of this recruitment is the result of the opening up of opportunities for smaller companies to undertake ventures that the larger companies are reluctant to pursue. One of the aims of PILOT[8] (an oil and gas industry task force) is to create 100,000 more jobs in the industry by 2010 in the UK. There

[6] Futureskills Scotland. Chemicals, Nuclear, Oil and Gas, Petroleum and Polymers, Scottish Sector Profile 2005 at Http://www.futureskillsscotland.org.uk/web/site/home/Reports/IndustrySector/Report

[7] Market Assessment for the Sector Skills Council for the Chemical, Nuclear, Oil and Gas, Petroleum and Polymer Industries Oil and Gas Industry Appendix Nov, 2003 Cogent

[8] http://www.pilottaskforce.co.uk/data/pvision.cfm

had been a lack of investment in training in the industry when oil prices were low but as prices have now increased an investment in training is beginning to occur.

The sector has recruitment difficulties as it is centred in the North East where unemployment rates are low. The sector traditionally recruits scientists and engineers from HE and also FE. They also recruit school leavers for Modern Apprenticeships. The need for improved generic skills in their workforce has been identified and their list of 'engineering base skills' includes the following -communication, team working, problem solving & diagnosis, taking responsibility & showing initiative, organisation and management.

This paper also highlights the upward trend in qualifications attained by the workforce noting that twice as many now go to university than 15 years ago. They however regretted that this had happened mainly at the expense of technical and vocational routes within Further Education as this had led to course closure of traditional NC and HNC routes which has had an adverse impact on manufacturing industries. Other papers have also highlighted this problem.

The Energy Industry

The Energy industry in Scotland currently employs 85,000 people, though this is projected to fall to around 65,000 on current trends. However, the Energy Industries Strategy Paper [9]sets out an ambition to increase employment in the domestic energy sector to around 100,000 by balancing the decline in offshore and gas sector with a growth in renewable energy, offshore and nuclear decommissioning. As oil and gas production declines in the North Sea there will be a need to decommission rigs and there is also the plan to develop new technology for renewable energy. Peterhead is the location chosen, by BP, for the world's first industrial-scale hydrogen power project which is designed to reduce greenhouse gas emissions by capturing carbon dioxide and storing it permanently in a safe, contained environment.

A recent report by Aberdeen Council[10] revealed that 50% of oil firms reported general recruitment difficulties and 66% had difficulties in recruiting particular occupations. Evidence suggested that shortages of managerial/professional and technical staff were more widespread than shortages of other skills. Information gathered in October 2005 by OPITO, from over 200 companies and the major trade associations, confirmed shortages across all sectors. A particular need for technicians was highlighted, while the drilling sector identified a workforce deficiency in 'floormen' and the sub-sea sector reporting a lack of sub-sea engineers. Difficulties in recruiting have been attributed to the generally tight Grampian labour market and high housing costs, coupled with international job opportunities, which potentially contribute to these problems. Some actions to improve the supply of new employees have been introduced, including technical training, careers information and guidance. In June 2006, a multi-million pound training programme was launched in Aberdeen to address immediate skills shortages in the oil and gas industry.

Life Sciences in Scotland

There are over 590 organisations in Scotland's life sciences community - employing over 29,500 people. Companies include LifeScan Scotland, Cyclacel, Optos, Ardana, ProStrakan, Scottish Biomedical, Invitrogen and Sigma-Aldrich.
500-plus new jobs are promised by the creation of the £59 million Scottish Centre for Regenerative Medicine (SCRM) in Edinburgh.

---

[9] Scottish Enterprise *Energy Industries Strategy,* 2005-2010

[10] The Energy Sector : Prepared for Aberdeen City and Shire Economic Forum by Aberdeen City Council and Aberdeenshire Council

However the director of a recruiting agency, which specialises in the biotechnology and life sciences sector, has predicted [11]that it may be a struggle to fill the jobs at graduate level. According to the Higher Education Statistics Agency[12] the number of students graduating in biological and physical science (this includes degrees in Allied to medicine) at Scottish institutions has risen from 11,865 in 2002/03 to 12,875 in 2005/06 and a paper produced in February 2007[13] for the Scottish Executive showed that in there had been a 69% rise in biological science graduates between 1997 and 2005 alongside a fall of 45% in chemistry, 9% in Physics and 12% in engineering. The figures in Table 4 below, from the report, show the number of graduates from HE courses over the period from 1990 – 2005. The recruiting director was worried about the type of biology degrees being offered and was not interested in degrees in subjects such as sports science and anatomy and wanted more graduates to specialise in disciplines which were more suited to the biotechnology and life science industries.

Table 4: Graduates from higher education courses in Scotland by subject of study: 1999-00 to 2004-05

Subject	1999-00[1]	2000-01[1]	2001-02[1]	2002-03[1]	2003-04[1]	2004-05[1]
All Subjects	**68,385**	**65,065**	**63,430**	**63,670**	**65,720**	**69,885**
Agriculture	1,140	1,175	1,030	880	985	985
Allied to Medicine	6,000	5,840	6,550	7,045	6,470	7,480
Architecture	2,395	2,335	1,915	1,905	2,080	2,250
Biological Sciences	2,470	2,770	2,855	3,160	3,255	3,605
Business Administration	16,815	15,275	14,160	14,165	13,930	14,025
Creative Arts	3,875	3,860	4,045	4,445	5,135	5,130
Education	4,670	4,030	4,615	4,470	4,445	5,375
Engineering and Technology	7,420	6,300	5,570	5,225	5,580	5,400
Humanities	1,295	1,235	1,315	1,580	1,415	1,625
Languages	1,595	1,760	1,490	1,525	1,415	1,540
Mass Communication	1,300	1,145	1,200	1,120	1,305	1,430
Mathematical Sciences	4,525	4,535	4,705	4,485	4,835	5,030
Medicine and Dentistry	1,160	1,100	1,260	1,175	1,330	1,340
Physical Sciences	1,985	1,850	1,610	1,660	1,645	1,790
Social Studies	7,405	7,350	7,120	7,265	8,100	8,895
Multi-Disciplinary Studies	4,330	4,510	3,995	3,560	3,800	3,990

Source: HESA, SFC
In this table, all numbers are rounded up or down to the nearest 5. Numbers may not sum to totals exactly due to rounding.

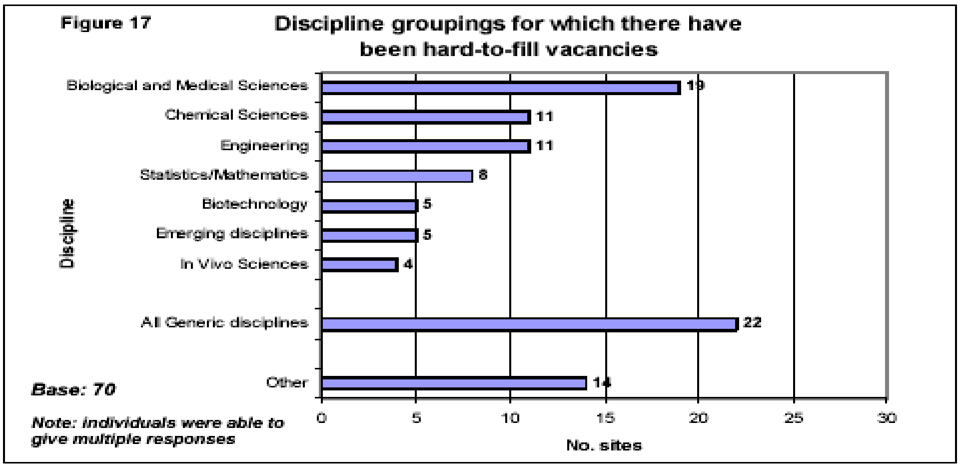


Figure from the SEMTA Report

A recent report by the Sector Skills Council for Science[14], Engineering and Manufacturing Technologies (SEMTA) also warned that the shortage of skills "has been reported with

[11] http://news.scotsman.com/topics.cfm?tid=116&id=274112007&format=print

[12] Higher education graduates and graduate destinations 2004/05, HESA,

[13] Supply and Demand for Science Graduates in Scotland, a review of available data, Report by the SE, the Scottish Funding Council and Futureskills Scotland

[14] Labour Market Survey of the Pharmaceutical and Bioscience sectors, SEMTA, 2006

increasing urgency by numerous organisations". In fact SEMTA's report indicated that 39 per cent of UK life sciences firms reported "hard-to-fill" posts. Scotland also reported a high level of hard to fill vacancies (49%). Overall, about half of the skills gaps are in scientific skills and half are in generic skills The most commonly cited scientific skills are bioscience and molecular biology and analytical and physical chemistry. This is shown in Figure 17 on the previous page from the SEMTA report.

SEMTA also reported that retaining staff in the industry could be a problem, as pay tends to be low at the basic level. The BioIndustry Association Scotland (BIA) has also stated [15]that while there was no shortage of graduates in Scotland, the skills of Scotland's graduates were "not best suited" to the industry and the numbers of students studying core disciplines, such as chemistry, was falling.

The BIA Scotland also think that greater investment is needed throughout the education system, from primary school to universities to allow more teaching of 'practicals', which they say are vital for engaging students at a young age; maintaining interest throughout secondary school and providing exposure to core skills relevant to the industry at University level.

They would also like to see a coordinated approach by the Scottish Executive departments of Education and Life Long Learning to bring about sector specific careers advice within schools, and the further and higher education sectors. They would be happy to help implement this coordinated approach.

Chemical Industry

There are currently over 200 chemical organisations operating in Scotland employing 16,000 people. 86% of the companies involved are SMEs. Scotland has just 5 % of the UK chemicals industry but this contributes 8 %of the Scottish manufacturing turnover with an annual output of more than £3 billion, and 12% (£1.7b) of Scotland's manufacturing exports, second only to the electronics industry. World scale companies such as AstraZeneca, Akzo Nobel, Avecia, Innovene, Ciba Specialty Chemicals, Exxon, GlaxoSmithKline, Rhodia and Syngenta have Scottish operations.

A report by the Skills Network Group of the Chemistry Leadership Council (CLC)[16] has made recommendations to shape the future agenda for Cogent and other Sector Skills Councils serving the chemicals industry. It states that the industry has significant skills gaps at both plant operator and graduate levels and has too few people trained and working to a minimum standard of NVQ Level 3 (A level Equivalent in England). Up-skilling the workforce is a major challenge. The industry, in the future, will probably need fewer but more highly skilled and technology-literate employees who will be able to work more flexibly across existing skills boundaries.

The CLC believes that there is a need for a better understanding of innovation processes and think that better ways for identifying future science, technology and engineering needs should be found so that the future skills and competences of the workforce can be identified. They have noted the fall in numbers of students studying the chemical sciences with concern and want ways found to encourage good students to study and take up careers in chemical sciences and engineering. They also want barriers between academic and vocational approaches broken down in subjects such as chemistry and chemical engineering. To encourage more creativity and innovation in the industry the CLC is keen to diversify its workforce by recruiting more females

[15] A manifesto for the Life Sciences in Scotland, BIA Scotland, 2006 at http://www.scotland.gov.uk/Resource/Doc/93978/0022602.pdf

[16] Skills for the 21st century chemicals industry, by the Skills Network Group of the Chemistry Leadership Council at www.chemistry.org.uk/pages/8/press/SKILLSREPORT.doc

and ethnic minorities. In schools in Scotland almost equal numbers of males/females study chemistry but this gender balance does not carry through to careers in the industry. It is argued that chemistry needs to be made more relevant and interesting to pupils and efforts made to publicise careers in the chemical industry.

The Food and Drink Industry

This sector employs over 55,000 people and contributes £6.7 billion per year to the Scottish economy. A report produced by Improve[17] on skills in the industry report does not mention recruitment of school leavers but examines future skills issues and asks what key skills require to be developed over the medium term. Basic computer literacy ranks high on their list. They also mention literacy, communication and oral communication skills, problem solving and team working.

Staff turnover is not high in this industry averaging 13% per annum. The job shortage vacancies in the skilled trades were for chefs and cooks, bakers and electricians and electrical fitters. In the meat sector of the industry vacancies were reported as hard-to-fill due to the poor attitudes, motivation and personality of applicants. Core skills deficiencies identified as particularly important to this industry were literacy, written & oral communication, problem solving and team working.

Review of High Value Electronics Manufacturing in Scotland[18]

The report published in May 2005 raised several points regarding skills and the labour market.

- It was felt that the media did not portray a positive image of the microelectronics industry and tended to focus on job losses rather than job creation. This has led to a tightening in the skills supply, as school leavers no longer see electronics manufacturing as an attractive career.
- Both the volume and the quality of job applicants are seen as problems. Direct labour supply has been described as 'tight' and quality, especially over the past three years, appears to have fallen markedly. Interviewees weren't clear why this decline had occurred but felt that a mix of poor educational standards and increasing opportunities in other service based sectors constrained supply. These problems are not unique to Scotland – similar issues are emerging in other parts of the world particularly in the Netherlands, other Western European states and in Singapore.
- The 'attitude' of direct labour to employment opportunities in the sector was considered to be poor.
- "Indirect" labour appears to have been the "saviour" of the sector. The high quality of engineers here and their ability to develop new processes and to apply their product development skills has given firms in Scotland a competitive advantage within their specific product niches.

Skills needs in Engineering

A report on skills needs in engineering[19] concludes that, while the supply of engineering qualified people has grown over the last ten years, engineering has clearly not been getting its share of the growing student population. Engineering also has had problems in attracting well qualified people on to Modern Apprenticeship programmes. Several reasons were given for this

---

[17] Skills needs in the Scottish Food and drink manufacturing Sector (June 2006) produced by Improve at www.improveltd.co.uk/web/Data/SNA_2.pdf

[18] Review of High Value Electronics Manufacturing in Scotland 2005 O'Herlihy & Co. Ltd, Glasgow. For Scottish Enterprise Electronics

[19] An Assessment of Skill Needs in Engineering, Connor H, Dench S, Bates P. DfEE Skills Dialogue SD2, 2001. ISBN: 978-1-84185-400-7

- a failure to attract enough of the right quality of young people to study engineering, partly due to a poor image
- fewer pupils taking maths and physics at 'A'/ H level
- continuing low take-up by women on engineering courses and MA programmes
- attractions of alternative options (especially IT)
- more encouragement given to young people to stay on at school than follow vocational routes which involve workplace training

Engineering is also criticised for losing too many graduates to other jobs (eg into IT and the City) and also for failing to use some of the engineering graduates appropriately and to develop their skills. Universities often have difficulty in recruiting young engineers on to their staff and it is felt that this can have a negative effect on Departments and on recruitment of potential students.

Skill deficiencies

Difficulties in filling vacancies are greater for engineering companies than for firms in the wider economy. Only the construction industry reports greater problems. Around one in six engineering employers have hard-to-fill vacancies and these are found at craft, technician, professional and managerial levels. Two-thirds of all vacancies at craft and skilled operative level are hard-to-fill ones, as are over half of all vacancies at engineering professional level. Particular areas of difficulty identified include: design engineers, CNC programmers, electrical engineers, fitters, pattern makers and CNC setter/operators.

75% of hard to fill vacancies in professional and technician grades were due to a shortage of suitably qualified applicants. At technician level it was difficult to recruit people with IT and software skills, while for craft level communications skills were wanted and for electronics difficulties were experienced recruiting graduate engineers.

3.4 Attracting talent from outwith Scotland

The Scottish Executive are worried about our skills shortages and are actively seeking people from Eastern Europe with their Talent Scotland[20] campaign. Their web site offers news and information on the Electronic Technologies, Life Sciences and Financial Services industries in Scotland with the job opportunities available and generally promotes the attractions of living in Scotland.

3.5 Graduates in the labour market

The UK has seen a rapid growth in the numbers entering Higher Education over the last 10 years: the number of undergraduate entering HE has risen by nearly 40%. The number of UK students accepted onto physical sciences courses has fallen from 15,000 in 1994 to just fewer than 14,000 in 2004 although the numbers choosing science degrees are increasing faster than those taking non-science degrees. Over the last decade the number of students (UK and foreign) completing undergraduate programmes in engineering and technology has remained relatively steady at around 20,000. During the same period the number of students completing programmes in biological sciences has grown by nearly 120%, with computer science courses also up by 159%.

[20] www.talentscotland.com

The UK with over 10% of 24 year olds holding a SET degree is only out-performed by South Korea and France. The UK has a higher percentage of SET graduates among 24 year olds than the United States and Germany. There has seen a fourfold growth in the percentage of first SET degree holders between 1975 and 2000.

Futureskills Scotland commissioned the production of a report[21] by the Institute of Employment Studies on graduate employment to find out if Scotland was producing too many graduates. This report describes how the labour market in Scotland for graduates changed between 1993/95 and 2001/03, and examines what effect the large increase in the supply of graduates in recent years has had on the labour market experience of graduates in Scotland. As the number of graduates in Scotland's workforce has increased by over 40% between 1995 and 2003 some people argue that there are 'too many' graduates, or at least 'too many' of the 'wrong type'. Others think that a modern economy needs graduate level skills to prosper. A final opinion is that the number and types of graduates produced match what Scotland's labour market and economy need.

The report argues that if there were too many graduates, some combination of the following would happen:

- graduate pay would fall
- the proportion of graduates in 'non-graduate' jobs would rise
- the graduate employment rate would fall relative to that for non graduates

For each of these points, the evidence is that the increased supply of graduates has been absorbed by increased demand.
Graduates can still expect to earn about 50% more than people who left school with roughly similar school qualifications.
There was almost no change in the proportion of graduates in non-graduate jobs between 1993-95 (17%) and 2001-03 (16%).
In 1993-95, 88% of working age graduates in Scotland were in work, compared with 79% of people with SVQ Level 3 and sub-degree Level 4 qualifications. In 2001-03 the figures were 89% and 84%. Graduates' advantage had narrowed because of the general improvement in job prospects, but the labour market advantage graduates enjoyed had been maintained.
The report concluded that there were not too many graduates and no evidence of too many of the wrong type. The report did not look at differences in employment opportunities for different types of degrees and instead only gives the overall picture.

3.6 General papers on skills

3.6.1 Skills in a global economy

In a report for Futureskills Scotland[22], Chris Humphries makes two important points on the changing structure of industries and jobs. First, the way in which the economy is changing is often misunderstood. While there is an increasing demand for people with high level skills, there is also a growing need for people to do jobs that need lower level skills. Secondly, the need to replace people who leave jobs – because they retire, move to another job etc. – creates more vacancies and training needs than 'new' jobs that arise from growing industries and occupations. Even industries that will suffer job losses will require new workers due to the ageing workforce.

[21] Labour Market for Graduates, Futureskills Scotland April, 2006

[22] Skills in a Global Economy Chris Humphries, Director General, City & Guilds for Futureskills Scotland

This means that there are opportunities for new workers in many manufacturing industries that have been in decline.

Over the last ten years, governments have realized the increasing importance of workforce skills as the extent of global competition has become clearer. The threats and opportunities posed by new technologies, the freeing up of international trade, and the increasing free movement of capital and labour, mean that the UK needs to be clear on where its strengths and opportunities for economic growth lie. The Government must make sure that the benefits of a strong economy spread to the population as a whole, and that the divide between the richer and poorer citizens becomes less, and does not widen further.

Skills matter greatly to a nation's prosperity especially in a time of great change. Increasing the skills base of the population will help the economy and also the individual. Raising skill levels is seen as a way to increase social mobility.

The main conclusions reached in this report are:

- too many young people are disengaging from learning and skills at age 17 (if not 14);
- major demographic changes will occur in the next 15 years in the UK workforce and this will make us more dependent on the skills of the existing working age population;
- rising skill levels are required in all occupations;
- the public need access to information on future labour market changes, and the mix of skills required for our future economy;
- too few people are pursuing essential craft, technical and trade skills at intermediate levels, leading to worsening skills shortages over the next ten years;
- there is serious imbalance between academic versus practical learning;
- too many adults with low skills and poor levels of literacy and numeracy;

The report goes on to say that for the UK economy to stay competitive the following must be addressed:

- the school system must serve **all** pupils
- adult literacy and numeracy must be improved
- public education and training should be employment led
- prioritise and invest in vocational education
- increase upskilling and reskilling in the workforce

and that a responsive 21st century education and training system should:

- be designed to serve **all** young people and adults
- respond to and anticipate labour demand
- properly balance academic and vocational skills
- achieve close integration between institutions and the workplace

These conclusions are reiterated in many of the papers in this report. There is a need for the education system to engage all pupils, to increase the basic skills of literacy and numeracy and to invest in vocational education to balance academic and vocational skills.

3.6.2 The Leitch Review

The Leitch Review was set up in 2004 to consider the UK's long-term skills needs and its report[23] was issued in December 2006. The purpose of the Review was to consider what the UK's long-term ambition should be for developing skills in order to maximise economic prosperity and productivity, and to improve social justice. For the UK to remain competitive it must continue to do as other developed nations and rely more on its ability to innovate to drive economic growth. The ability to do this will depend on the skills and knowledge of the workforce.

The Review's interim report, published in December 2005, found that the UK's skills base lags far behind that of many advanced countries. The challenge of delivering economically valuable skills has been a longstanding concern, as the Leitch Review quoted "Even back in 1776, Adam Smith's *'The Wealth of Nations'* suggested that *'the greater part of what is taught in schools and universities … does not seem to be the proper preparation for that of business'.* " Leitch concludes in his report that UK skills are not world class and that this may undermine our long-term prosperity. Productivity is also lower than for many competitors and the UK has high levels of child poverty, high regional income disparity and high unemployment rates for the disadvantaged. Improving skill levels can help all these problems. As can be seen from the chart below (from the Leitch report) showing child poverty rates in EU countries the UK has, for a 'prosperous' nation, a high level of child poverty.

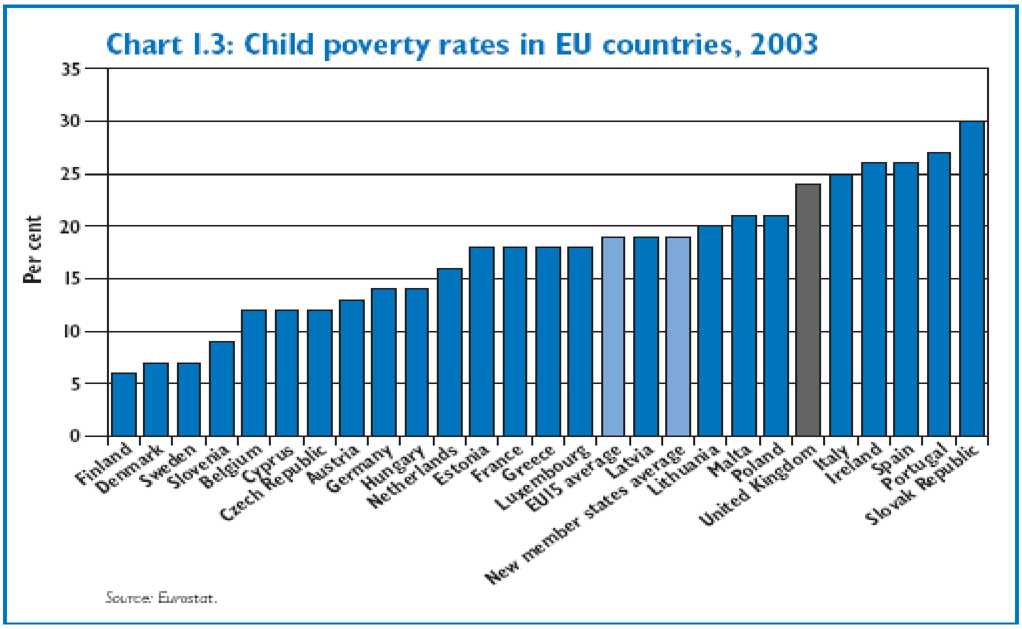


Chart 1.3: Child poverty rates in EU countries, 2003

Source: Eurostat.

[27] Barclays Bank, 2001 in *Urban renaissance of EU non-capital cities*, Parkinson et al, 2004.

[28] Child poverty can be measured in a number of ways. The most common, and the one used by the Government, is the proportion of children living in households with less than 60 per cent of median income.

While large numbers are going on to university and the numbers taking up Modern Apprenticeships are increasing there are still too many adults who have difficulty with numbers (one half of adults) and one seventh are not functionally literate. Our intermediate and technical skills also lag behind other countries and we do not have the quality or quantity of vocational skills required. Over one quarter of adults hold a degree but this is fewer than in many other countries.

[23] Leitch Review of Skills, Prosperity for all in the global economy- world class skills, Final Report, December 2006 at www.hm-treasury.gov.uk/independent_reviews/leitch_review/review_leitch_index.cfm

Skills policy in the UK is devolved. The Review has worked closely with the administrations from Scotland, Wales and Northern. In Scotland, the themes of this report will now be taken into and debated under the auspices of the Scottish Executive's consultation *Lifelong Learning – Building Success: A discussion of specific issues related to lifelong learning in Scotland,* published in November 2006.

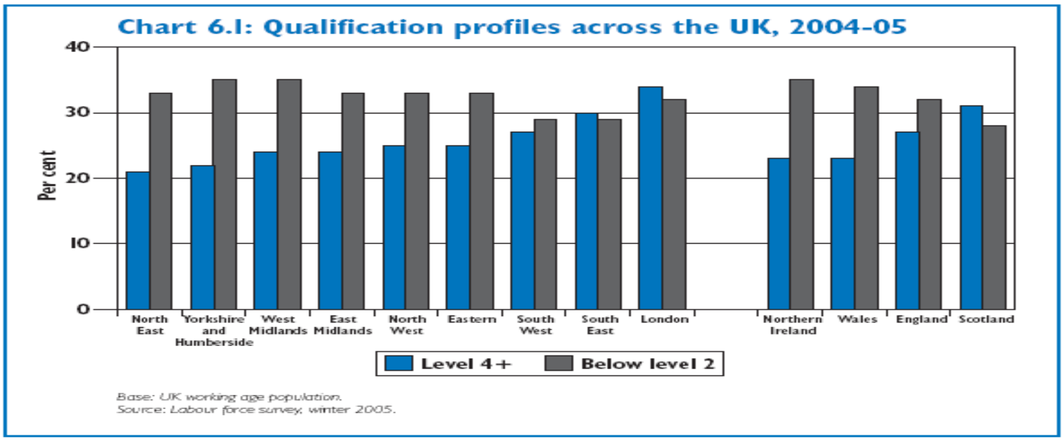


Chart 6.1: Qualification profiles across the UK, 2004-05

Referring to the above chart from the Report, Scotland has a relatively higher proportion of its working age population qualified to level 4+ and a lower proportion below Level 2, but this latter figure is still 28%.

It is difficult to find separate details of the levels of numeracy and literacy in Scotland but it is reckoned that there are up to 800,000 adults who appear to have very low skills and up to 500,000 assess their own skills as poor or moderate.

A significant piece of research that has influenced policy in many countries is *'The International Adult Literacy Survey'* (IALS)[24]. It concludes that 23% of adults in Scotland may have low skills and another 30% may find their skills inadequate to meet the demands of the 'knowledge society' and the 'information age'. In comparison with other countries, Scotland and Great Britain are well down the league of OECD (Organisation for Economic Co-operation and Development) countries participating in IALS, with a greater proportion of their population at the lowest of the five levels of performance.

- significant numbers of those performing at the lowest level rate their own skills as poor or moderate (almost 60% of those at Level 1 rate their mathematics skills low and over 40% their writing skills).
- although the great majority (93%) of the population are generally satisfied with their skills, 1 in 4 of those who rate their reading or writing skills low say they are dissatisfied.
- of the three skills (reading, writing and mathematics), more of those performing at Level 2 say their mathematics skills limit job opportunities. Among those performing at Level 1, as many as 1 in 5 say their reading skills limit job opportunities.

In October 2006 the Scottish Executive issued a consultation document[25] on specific issues related to lifelong learning which was a follow up to their 2003 *Lifelong Learning Strategy: Life through Learning; Learning through Life.* This seeks to engage with employers and the public at

[24] Report from the Scottish Executive at http://www.scotland.gov.uk/library3/lifelong/alan-03.asp

[25]http://www. scottishexecutive.gov.uk/Resource/Doc/156857/0042190

large to help develop skills, knowledge and attitudes to strengthen Scotland's economy and society.

The Leitch report focuses on adult skills as most of the current workforce has completed their education but also suggests that action be taken in schools to develop economically valuable skills. Key skills applicable in most jobs include:

- basic skills such as literacy and numeracy
- generic skills such as team working, problem solving and communication

Specific skills are less transferable but most occupations use a mixture of different types of skill. These skills and their level can be measured by qualifications which can be obtained in a number of ways. The report recommends expanding the existing Modern Apprenticeship scheme to increase numbers to 500,000 by 2020 (in the UK) and wants to encourage employers to get more involved, so that every young person with the right qualifications will be able to take up an Apprenticeship place. Many in the UK hold vocational skills in low esteem and work must be done to improve the image of people with these skills. FE colleges can help with this by publicising the employment and pay prospects of their students. Doing this will show that obtaining a vocational qualification, such as an HNC, is worthwhile and will greatly improve career aspirations. It is somewhat ironic that obtaining vocational qualifications is now something to be encouraged as for the last 10 years FE colleges have increasingly downsized or even closed science and engineering departments due to a very unfavourable funding regime for such courses.

3.6.3 Projected need for engineers and scientists[26]

This report argues that UK business is facing a recruitment battle, with 40% of employers saying that they do not expect to meet their engineering and technician needs over the next four years. 45% of those surveyed who were planning expansion said that they could not recruit suitably qualified staff in the UK. This recruitment problem seems to be nationwide although it was most problematic in the South East and pretty evenly spread elsewhere across the UK. Several were planning to move their business abroad as they did not think that the recruitment situation was going to improve due to the decline in numbers of those studying engineering at universities. The CEO of the IET, Dr Alf Roberts expresses concern about the lack of engineers noting that UCAS figures show that some engineering disciplines are down by nearly 20%. The survey also showed that there were concerns about the amount of training new graduates required and employers highlighted the need to improve links between industry and the universities to help produce more relevant study options.

The report goes on to suggest what needs to be done. The top recommendations involved schools, seeking investment for better resources, more practical work and action to improve the image of engineering and technology.

A further report by the Henley Management College for the Royal Academy of Engineering[27] again expresses concern 'over the long-term pipeline of young talent going from schools on to

---

[26] The Institution of Engineering and Technology report[26], May 2006: Engineering and Technology Skills and demand in Industry : summary of survey findings

[27] Educating Engineers for the 21st century: the Industry View by the Henley Management College for the Royal Academy of Engineering (2006)

university engineering courses and subsequently into engineering firms'. They also reported that between 40-70% of firms reported recruitment difficulties as shown in their table below.

Type of Engineer	**Number of firms recruiting**	**Difficult to recruit**	
		Count	**%**
Building services	14	10	71.4
Systems engineering	99	60	60.6
Civil	25	15	60.0
Electrical/ electronic	169	99	58.6
Production/Manufacturing	119	59	49.6
Chemical	34	15	44.1
Mechanical	209	89	42.6
Computer	109	46	42.2

Table: Recruitment Difficulties

Many employers, interviewed for the Henley report, raised concerns over mathematical skills, a concern that several interviewees traced back to what they saw as the deficiency in mathematics teaching in schools. The report quotes one senior executive as follows: '*there are some basic mathematical capabilities issues. I think the maths teaching is not what it was, or it is, but our demand exceeds our capacity. So our demand to churn out people with maths skills exceeds our capacity to teach them. And I'm not just talking about university; I'm talking about schools'.*

This report also comments on the image of the engineering industry and its ability to attract talented pupils from school on to engineering courses and into the industry. As one interviewee saw it *'rather than beating up the universities for failing to inculcate certain skills, I prefer to beat up the universities for not attracting in the right people. It starts in the schools, getting the right engagement'.* In this connection there was a feeling that pupils did not want to take what were seen as difficult subjects like engineering, physics and mathematics. '*Many courses in engineering are perceived as being hard, in the time that's required, and boring'* commented one respondent, adding that *'if you want people to go and be engineers you've got to make it a bloody sight more fun'.*

3.6.4 CBI Scotland Report

CBI Scotland produced a report[28] in which they aired their concerns that 'the decline in popularity of science and maths in schools and the subsequent fall in graduate numbers will leave Scotland short of the engineering, science and technology skills the economy will increasingly need.' They went on to state that *'Careers advisers lack the knowledge to communicate effectively the full range of options and opportunities within Scottish business for young people.'* Their recommendations were for:

- all business-education links to be rationalised and focussed through *Determined to Succeed*
- tailor-made training to address specific skill shortages
- root and branch reform of Careers Scotland
- SE and Scottish business to encourage greater uptake of science and mathematics in schools.

[28] The Scottish Economy: Priority of Priorities, September 2006

The CBI report also goes on to state that *"Schools are failing to engage meaningfully with too many young people, leaving them far short of being 'work-ready', often with few or no qualifications and little to show for the years spent in classrooms". "As a consequence, Scottish businesses have to invest an unacceptably high proportion of the £2 billion they commit to training annually on what is effectively remedial education, rather than on sharpening their competitive edge."* Some of this £2 billion was spent on improving the literacy and numeracy of school leavers. The skills that the CBI would wish better developed in school leavers are:

- literacy and numeracy
- communication and team working
- problem solving
- adaptability and flexibility
- awareness and understanding of enterprise

The CBI also replied to the Executive's Consultation paper on their Science and Innovation Strategy again stating that they were concerned with the numbers taking science and mathematics at school and university and the lack of good career advise in schools. They also asked the Scottish Executive to consider examining whether the re-weighting of Education Maintenance Allowances in favour of science subjects might increase the attractiveness of these courses for pupils and asked them to think of setting targets for the number of students entering Science, Maths, engineering and technology courses. The CBI also supported increasing the public engagement with science in the hope this would keep parents involved and if parents are better informed about the benefits of an education in science and the job opportunities that it can offer, they could influence their children to take up a career in science.

3.6.5 The Federation of Small Businesses and Futureskills Scotland reports

A Federation of Small Businesses (FBS) paper in 2006[29] identified skill shortages found when trying to recruit staff but said that only 40% of businesses actually report finding skills lacking. The skill shortages were listed as follows.

Table3.6.5.1: Skill Shortages when trying to recruit new staff

	Count	% Businesses	% Responding
Technical skills	189	9.50	44.30
Literacy	179	9.00	41.90
Communication	174	8.80	40.70
Customer service	173	8.70	40.50
Numeracy	167	8.40	39.10
Basic IT skills	90	4.50	21.0
Advanced IT skills	83	4.20	19.40
Sales and Marketing	83	4.20	19.40
Managerial skills	69	3.50	16.20
Foreign Languages	40	2.00	9.40

Futureskills Scotland[30] also surveyed the small business sector to find the major challenges facing these businesses. Employers were asked if they recruited employees directly from secondary school, FE or HE and, if so, how well prepared these employees were. From Table 3.6.5.2.it can be seen that for very small firm employers that recruited directly, there was

[29] Lifting the Barriers to Growth in UK Small Businesses at www.fsb.org.uk/barriers2004/Tables.pdf
[30] http://www.fsb.org.uk/documentstore/filedetails.asp?id=274

little variation in the perceived level of readiness for employment between recruits at different levels. Larger firms tended to rate applicants from HE/FE as better prepared for work as shown below. This is shown in the table below:

Table3.6.5.2: Employers who had recruited from schools/FE and HE. Percentage who reported that employees were well prepared for work

Employees from	Number of Employees in company		
	1-9	10-49	50+
School	64	56	58
FE	59	73	77
HE	59	76	75

Table3.6.5.3: Skills lacking in job applicants

Skills lacking in % of applicants for skills vacancies	Number of Employees in company		
	1-9	10-49	50+
Oral communication	58%	49%	37%
Problem solving	54%	36%	34%
Team working	46%	50%	39%
Written communication	50%	31%	25%
Planning and organising	47%	34%	28%
Technical/ practical skills	14%	30%	27%

Although skills were not given as one of the main challenges faced by companies 60% reported skills deficiencies in applicants for posts, as shown in the above table 3.6.5.3 from figures given in the same report. Small companies are generally more dissatisfied than larger companies but whether this is due to the fact that the larger employers get their pick of applicants or whether in a small company a new entrant is expected to be more independent more quickly it is difficult to say. Generally it was the basic skills of communication, team working and problem solving, which were of most concern, rather than technical and practical skills.

The FSB have also asked for a review of the target of 30,000 MAs and queried if this is ambitious enough, due to the difficulties being experienced particularly in the construction industry. They also wanted the profile of vocational education to be raised so that it is regarded as of equal value to Higher and Further education. The two reports categorise skills differently but both highlight communications skills and customer handling skills as problem areas. The FSB also reports deficiencies in numeracy.

The FSB also argued that new thinking is needed so that all young people leave school with the key skills sought by employers. They note that research has shown that the first seven or eight years of a child's life are the most important in establishing patterns of learning, IQ, and social skills, so investment must be targeted at this stage of education. In addition, it was argued that soft skills development should be given greater priority in FE/HE and industry training programmes.

3.6.6 Public perceptions of SET

A number of studies[31] have looked at the public's perceptions of science, engineering and technology (SET) and the main conclusions are given below:

[31] Engineering UK 2005, etb Research Report November 2005; ROSE Survey in Scotland at http://www.gla.ac.uk/STEM; Educating Engineers for the 21st Century: The Industry View, The Royal Academy of Engineering; The Institution of Engineering and Technology- Engineering and technology Skills and Demand in Industry, 2006

- adult perceptions of SET are positive – most of the adult population feel that science and engineering have a positive impact to make to the UK economy
- adults do not have an up-to-date view of science and engineering
- the public understands of the role of science and scientists better than that of engineering and engineers.
- people in the UK have a less favourable view of engineering than their European counterparts
- teachers are not sure of career paths to engineering, or what qualifications are needed, and they also see engineering as a dirty, old-fashioned and predominately male orientated career
- pupils have a more up-to-date view of the engineering profession with most pupils feeling that engineering is important to day-to-day life and associated with transport, new technology and computing
- pupils in Scotland have a disappointing level of interest in school science at the S3 stage of secondary school, although they show most interest in topics with a personal or human interest.

Career choice

- research indicates that the main reason for choosing engineering as a career is that pupils were interested in engineering, and that they had a role model, a father or relative, who was already working as an engineer
- pupils appear to be influenced by "significant others", such as parents, relations, friends, teachers and careers advisers
- decisions about jobs are made at an early age, at least by age 11 to 14.
- information and guidance is complicated by the choice of subjects and the different levels of qualifications available post-16 and by the competition between the needs of institutions to compete for young people's choices in the education and training market place
- as poor subject choices made early on at school can block whole areas of science, engineering and technology (SET) later on, it is hoped that early guidance can be given rather than simply alerting young people to what is available
- it has been found that school pupils use a wide range of sources of information to gather information on careers and these sources influence them
- many pupils would welcome more information about SET careers and the range of opportunities available

3.6.7 SET Skills in the UK[32]

In 2004, the ten-year science and innovation investment framework for the UK outlined a vision for further improving the UK's already strong science base. It also aims to increase total expenditure on R&D as a percentage of Gross Domestic Product (GDP) from 1.9 per cent to 2.5 per cent by 2014. To meet these ambitions it was realized that there was the need for a suitable supply of people with qualifications in science, engineering and technology (SET). The schools, FE and HE will need to be involved to help attract sufficient young people to study in the STEM disciplines. The framework wanted:

- improvements in the quality of science teaching in every school, college and university
- better results for pupils studying science at GCSE level

[32] DTI ECONOMICS PAPER NO.16 Science, Engineering and Technology Skills in the UK, MARCH 2006

- an increase in the numbers choosing SET subjects in post-16 and in higher education
- an increased proportion of better qualified students pursuing R&D careers
- the proportion of ethnic minority and women studying SET subjects in HE to be increased

Concerns have often been raised within the UK, US and other OECD countries about the supply of SET skills and the apparent decline in interest to study these subjects. Given the importance attached to innovation policy, it is important to monitor the market for SET skills, both in terms of demand and supply.

Trends in SET qualifications

There was an increase of 57% in the numbers of first degree SET graduates living in the UK between 1997 (1.3 million) and 2004 (2.1 million). These figures are taken from the Table shown below from the DTI publication. The number of graduates has risen substantially in computer sciences, subjects allied to medicine and biological sciences. While there has been a decline in engineering and technology, physical sciences and architecture graduates as is shown on the graph on the next page.

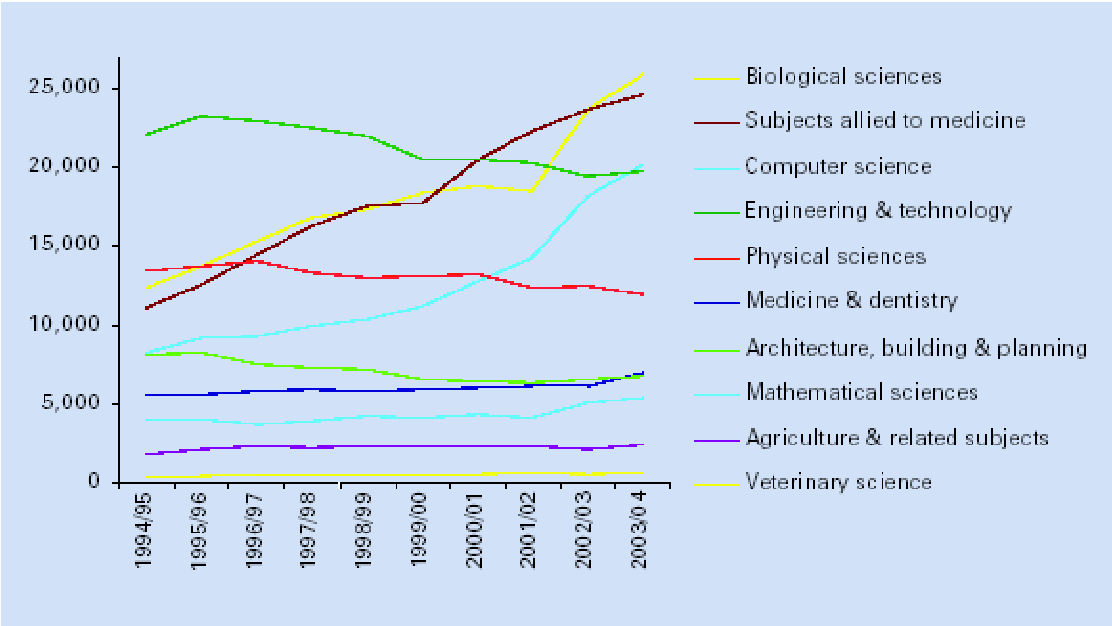
First Degree Graduates

		1997	2000	2004	% increase 1997-2004
SET subjects	Absolute number As % of working age population	1 350 000 3.9%	1 669 000 4.8%	2 123 000 6.0%	57.2%
Non-SET subjects	Absolute number As % of working age population	1 788 000 5.2%	2 189 000 6.3%	2 670 000 7.6%	49.3%

Source: Labour Force Survey, Autumn data, GB, single subject degrees and working age only (16-59/64)

The proportion of female SET graduates has risen from 27 per cent in 1997 to 36 percent in 2004. Large numbers of women study biology and medicine, but few still take an engineering degree. Since 2001 there has also been some growth in the proportion of SET graduates from ethnic minority groups. The Figure on the next page shows the growth in the number of SET first degrees obtained by subject from 1995 to 2004. It will be noted that numbers are increasing in the biological sciences and in subjects allied to medicine but that numbers are in decline for engineering and the physical sciences in the UK.

SET first degrees obtained by subject



Source: Higher Education Statistics Agency. 2002/03 and 2003/04 data not directly comparable with previous years due to changes in the subject classification system and to the treatment of combined degrees.

3.6.8 Occupational segregation in Scotland[33]

In Scotland five sectors currently identified as experiencing skills deficiencies are engineering, construction, plumbing, ICT and childcare. The Equal Opportunities Commission looked at occupational segregation in these areas and concluded that segregation of men and women into different types of employment has a damaging effect on the economy by failing to make use of the potential workforce and contributing to skills deficits that damage the economy. This also has the effect of placing women in low paid, low status jobs. Modern Apprenticeships (MA) appeared to contribute to this segregation at present although the scheme could be used as a way to give greater career opportunities for all.

Number of Modern Apprentices in areas where there are skills shortages

Area	Females	Males
Construction	41	5807
Engineering	50	2034
Plumbing	4	1234

In construction 60% of hard-to-fill vacancies were attributed to skill shortages and in engineering continuing problems with skills shortages were predicted over the next five years. One of the reasons given why it is difficult to recruit more females to MA schemes in these areas is the lack of 'parity of esteem' between FE and HE. Girls leaving school did not hold the FE qualification of an HNC/HND in high regard. The schools seem to encourage any pupil who takes Highers to go to University and do not see the alternative route via an HNC to a degree as a valuable alternative.

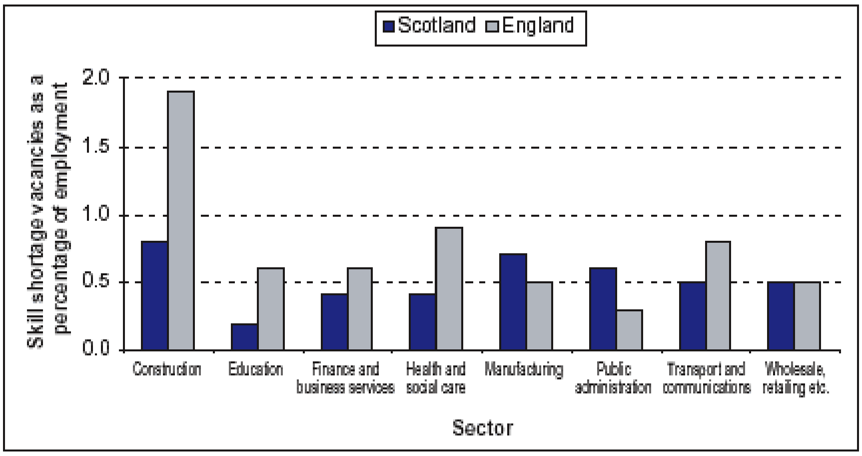
[33] EOC 2003 investigation at www.eoc.org.uk/Default.aspx?page=19303

Employers also do not often encourage girls to take up apprenticeships, as they may not think that they have the facilities for them and may be concerned how their workers will treat a female employee. Female apprentices can have a rough time and many give up because of this.

The way in which careers advice and subject choice is provided in schools was identified as limiting the numbers of potential applicants. Extending the role of hands-on occupational tasters was regarded as a useful way to recruit more girls. The report recommends that a national strategy needs to be developed to tackle gender segregation in education, training and work to ensure that employers have the right skills to support success. It also urges careers advisers and teachers to promote the advantages of the MA programme as well as other educational options.

3.6.9 Skills deficiencies in the engineering industry among existing employees[34]

Skill deficiencies in the existing engineering workforce are also noticeable, in particular in the engineering occupations shown above as having recruitment difficulties. One in four engineering employers consider that there is a gap between the skills of their current workforce and those needed to meet their business objectives. The nature of these skill gaps also mirrors those experienced in recruitment difficulties, with an emphasis on practical and technical skills, but the personal and generic skills are also mentioned. In particular, people management skills are seen to be very important at all levels and it is here that deficiencies are commonly reported. The figure below, from data provided by Future Skills Scotland[35] compares the situation in Scotland with that of England. It will be seen that for most sectors there are fewer skill shortages in Scotland with the exception of the manufacturing industry and public administration.



Source: Skills in Scotland 2002, The Employers' View: Future Skills Scotland

The report goes on to say that the shape and structure of the engineering industry has changed over many years and this has seen a shift in demand towards a more skilled and educated workforce. There is forecast to be a growth in demand for professional engineers of 2% per year until 2009 and in the same time a reduction of 2% in engineering craft and metal working trades. The replacement demand is likely to outweigh the effects of contraction in the

34 *An Assessment of Skill Needs in Engineering*, Connor H, Dench S, Bates P. DfEE Skills Dialogue SD2, 2001. ISBN: 978-1-84185-400-7

35 Skill Shortages in the UK at www.futureskillsscotland.org.uk/web/site/home/Reports/WhatEmployersThink

industry. Companies are having to change their skill mix, through upskilling of existing employees and recruiting at higher levels.

The numbers of first degree graduates in engineering and technology is just over 22,000, a similar level to 1995 although substantially higher than in 1988.

International comparisons show that the UK still has fewer people trained at the intermediate level than most countries although it produces as many engineering graduates.

While the supply of engineering qualified people has been growing over the last decade, engineering has clearly not been getting its share of the growing student population. Engineering also has had problems in attracting people of sufficient calibre on to Modern Apprenticeship programmes. The report goes on to give reasons for these problems, which have also been highlighted, in other sections of this report:

- a failure to attract enough of the right quality of young people to study engineering, partly due to the poor image of the industry
- fewer pupils studying maths and physics at 'A' level
- the low uptake by women on engineering courses
- the attraction of alternative options (especially studying IT, although this also seems to be beginning to decline)
- more encouragement given to young people to stay on at school than follow vocational routes which involve workplace training.

3.6.10 Projected demand for scientists

According to estimates published by Futureskills Scotland[36], more people with higher level qualifications will be required in the future (estimates based on demand from 2002 to 2075).
A recent paper by the Scottish Executive [37]attempts to predict the demand for scientists in 2014 and estimates that there will be an increase in total employment of 12%.
The overall outlook for science occupations looks positive in the future with employment in science occupations anticipated to grow at a faster rate between 2004 and 2014 than is expected for other occupations (Figure 1).

- Total employment in science occupations is anticipated to rise from 261,000 jobs in 2004 to 292,000 jobs in 2014. This is an increase in total employment of 12%.

In general there will be a move from lower skilled jobs to higher skilled and professional ones. The projections for the economy as a whole show that professional and associate professional occupations are expected to dominate employment growth.

[36] Labour Market Projections for Rural and non-rural Scotland report produced by IER for Futureskills Scotland
[37] Supply of, and Demand for Science Graduates in Scotland: a review of the available data, Report by the Scottish Executive, the Scottish Funding Council and Futureskills Scotland.

The table below from the report shows the projected employment numbers in occupations from 1984 to 2014.

Figure 1: Historical and projected employment for science and non-science occupations, 1984 to 2014

	1984	1994	2004	2009	2014
Science professionals	46,000	59,000	79,000	85,000	91,000
Health professionals	15,000	20,000	25,000	27,000	31,000
Science and technology associate professionals	34,000	42,000	53,000	56,000	60,000
Health associate professionals	76,000	91,000	104,000	107,000	110,000
All science occupations	171,000	212,000	261,000	276,000	292,000
Non-science occupations	2,064,000	2,157,000	2,261,000	2,267,000	2,280,000

David Lonsdale of the CBI said "Our members fear Scotland will be left short of the engineering and technology skills that are so important to crucial industries such as renewable and nuclear energy, oil and gas, electronics and aerospace" .
Duncan McSporran, director of the Engineering Development Trust in Scotland, which visits schools to encourage more pupils to take up science subjects, added that the problem could be traced to choices made at primary and secondary school levels.
"The perception still exists that an engineer is a person with a cloth cap and a big spanner and that engineering is in decline but that is simply not the case," he said.

Shortages for graduates are mainly in occupations needing specific higher education skills and Science and Engineering continue to be among the top skill shortage areas. There is also a relative shortage in public sector associate professionals such as environmental health officers and careers advisers.

4. COMPARISON WITH VIEWS OF OTHER STAKEHOLDERS

4.1 The universities

In 2005 we published our report '*Science Education for the Future*'[38]. This summarised the conclusions of a project funded by the SEED and carried out across all the Scottish universities, seeking to articulate what academics believed should be most important in the school education of students going on to study STEM subjects at university. The discussions revealed a remarkable level of consensus among academics representing science, engineering, medical and computing disciplines. The summary of conclusions was as follows.

- The universities would strongly favour a less crowded, less assessment driven and more flexible curriculum for all levels of science courses, aimed to liberate and enthuse both teachers and learners.
- We believe the national report, *"A Curriculum for Excellence"*, sets an ideal framework for a fundamental review of science education.
- Falling numbers taking science Highers have serious implications for the supply of STEM qualified graduates and for the future health of the science base and economy of Scotland.
- A strong scientific literacy theme should form a vital part of school education for all pupils.
- Developing personal study and work attitudes is important and needs to be considered in curriculum design.
- Building key scientific skills should be a much stronger focus across the range of STEM subjects in school.
- A seamless 3-18 curriculum is needed, avoiding current 'disconnects' in continuity and relative difficulty between different stages.
- Mathematics provides a vital underpinning to students wishing to study STEM subjects at university. The curriculum should ideally build a mastery of basic techniques, particularly algebra. Topic content needs to be strengthened rather than thinned. Developing student skills in mathematics should be reinforced in the science curriculum.
- The science subjects at school are viewed as overloaded and lacking in obvious relevance to everyday life: we recommend clarified and driving aims for school science education and we suggest that research on how to engage pupil interest should also be undertaken to inform a successful curriculum redesign.
- It is important to build understanding of the core principles of the sciences; more themed or applications led approaches could be considered; more extended practical work and more in-depth and open-ended activities should be introduced.
- The position and status of technological studies, the only school subject pointed explicitly to the world of engineering, needs urgent review; representatives from industry and the appropriate professional associations could be consulted to help with this.
- Universities believe that the school computing curriculum gives a misleading impression of the nature of the discipline of computing science as studied in Higher Education.
- The design of assessment, particularly in science, must be radically altered if the proposed shift in curriculum emphasis is to be realised.
- Fruitful cross-curricular links should be explored amongst the sciences but also more widely with other subjects and in support of the key themes of enterprise, creativity and citizenship.
- We tentatively draw attention to an approach, which might be investigated to improve the gender balance in some subjects.

[38] Science Education for the Future, *John Coggins, Moira Finlayson and Alan Roach - at* http://www.gla.ac.uk/stem

On the whole these views chime coherently with the messages from industry reviewed in this study. Not surprisingly, the universities made more specific comment on the subject matter of what is taught in schools and on the effects of assessment methods. However, the crucial importance of attempting to nurture attitudes was very strongly emphasised, as was the need to focus on relevant skills. Work attitudes were regarded as important and academics were keen to see schools better engage pupils and to encourage pupils to develop a 'work ethic'. For science, the important 'knowledge' was associated with the bigger picture: 'understanding the core principles of science.' Numeracy was seen as a key characteristic for successful practice in any of the STEM disciplines. 'Literacy' was also much stressed, and developing skills in coherent scientific explanation, and in logical argument, were seen as contributing important and transferable components to this.

There were echoes of the industry view that many school leavers have extremely limited practical skills and also that the image of engineering needed to be raised in schools where it is often regarded as for less able pupils. The university sector also raised concern with the status and content of Technological Studies. Gender imbalances are also of shared concern.

The university report recognised the importance of engaging the interest and developing appropriate skills in those who might progress into industry at craft and operator levels, but here the industry voice is more strongly and convincingly expressed. Industry also stresses more the importance of well-informed careers advice and of practical work experience.

Industry has clearly articulated the importance of both career advice and appropriate schooling to secure a stream of well-prepared candidates for technical Modern Apprenticeships. Employers have voiced specific concern that pupils are being encouraged to stay on at school and not to consider apprenticeship routes.

4.2 Teacher bodies

Having looked at what industry and universities think of STEM education in schools, let us have a quick glance at what a body of teachers are thinking. In response to the publication of the *A Curriculum for Excellence* the Association for Science Education Scotland made a submission to the Scottish Executive, with the following summary.

ASE Scotland statement following publication of ACfE report: summary.

We would ask the Review Committee to consider the following points.

1. *To consider and reformulate the purpose and aims of formal education and the contribution that science can make to these aims.*
2. *To initiate a comprehensive review of the purpose and influence of summative high-stakes assessment and the effect it has on the quality of the teaching and learning experience in Scottish schools.*
3. *To consider alternative models for a science curriculum, in particular to consider a curriculum for all learners, based on a citizenship agenda, which is founded on understanding the nature of science, the cultural legacy of science and the confidence to engage in scientific issues.*
4. *To strive for a CPD strategy which aspires to change the nature of how science is presented to children, building on the lessons learnt from 'assessment for learning' and constructivist research.*
5. *To recognise that the science community in Scotland will not be able to change direction overnight. These reformulated principles will need time before the teaching community*

feels able to move in new directions. However, such inertia should not be allowed to prevent brave reform. Scotland needs to start this long process now and recognise that such an investment in change might take about ten years to achieve.

This offers a quite different perspective on the school curriculum and they question the fundamental purpose of science education in schools and the role assessment plays in stifling real understanding and interest in the subject. They are keen to engage in the science citizenship agenda and to start curriculum design with a clean sheet of paper. They also highlight the practical imperatives of professional development for teachers and design of support materials, necessary to implement radical change.

Prominent ASE members have long argued for more emphasis on skills development and a focus on 'the big ideas of science'.

The Scottish Mathematical Council is also a strong proponent of change along the lines being argued. They too wish for a stronger emphasis on mastery through practice of basic mathematical skills, and are keen to see engagement with teachers of other STEM disciplines in reinforcing and bringing to life these skills, showing their power through relevant applications.

The Executive Committee of the Scottish Technology Teachers Organisation has long been concerned about the Cinderella status of their subject and will readily cooperate with moves to address these issues.

4.3 What about the pupils?

What about the most important group of people in this equation – the pupils? What do they think of science and of current school science education? Last year we ran the international ROSE Survey (Relevance of Science Education) in Scotland[39]. This questionnaire has over 250 questions and asks pupils their likes and dislikes on a large number of science topics. It also asks questions about their future job, the environment, their science classes, opinions of science and technology and out of school experiences.

This survey had already been carried out in over 40 countries and we were funded by the Scottish Executive Enterprise Transport & Lifelong Learning Department to conduct the Questionnaire in Scotland. We surveyed 160 class groups of Secondary 3 pupils (most of age 14) across 92 schools, collected over 2,700 validly completed returns and electronically encoded them. The sample was geographically, socially and educationally representative.

A summary of conclusions is given below:

International comparisons

- the sample-averaged responses from Scotland are broadly similar to those from developed countries in general, quite close to those from England, and closest of all to those from Northern Ireland
- <u>views are net negative overall</u>: the survey reflects what many will regard as, overall, disappointingly negative views of science & technology, and of learning experienced at school

[39] The ROSE Survey in Scotland – An Initial Report, S. Farmer, M. Finlayson, B. Kibble & A. Roach at http://www.gla.ac.uk/stem

- there is a diversity of individual views on most issues: whilst we see clear majority views for pupils as a whole or for pupils in a given gender, course or social group, there are very often significant minorities with contrary opinions
- variation by gender: girls are on the whole rather more negative about science, and especially technology, and they have somewhat different relative preferences and attitudes
- variation by course of study: pupil opinion is generally substantially more negative for those studying fewer separate science subjects or the lower level curriculum – the subgroup taking all three separate science courses was the only group where a majority agreed: "I like school science better than most other subjects"

Social, economic, domestic and school background

- significance of the number of books at home: the only question in the survey related to individual circumstances was to estimate the number of books in the pupil's home - the answers given correlate, more strongly than any other indicator we have studied, to very significant differences in attitudes to and interests in science
- limited relevance of school free meals indicator, or geographic area: overall interest in science seems little related to the social catchment of the school as reflected in the percentage of pupils eligible for free meals, and preliminary study reveal little difference between pupils in Glasgow and those in the Highlands
- evidence of a 'class effect': some class groups responded much more positively (or negatively) than apparently similar classes in other schools - this might reflect the impact of a teacher, the school, or a particular peer group influence and is worthy of further study

Attitudes to science, technology and the environment

- doubt whether science is net beneficial: by a small majority, overall, pupils did not agree that "the benefits of science are greater than the harmful effects it could have" - the proportion agreeing with the statement varied between two-thirds and one-third for subgroups following different study routes
- lack of trust in scientists: under 17% of pupils felt able to agree that "we should always trust what scientists have to say" – we regard this as perhaps the crucial obstacle for those seeking to enhance public understanding of science, and a wake-up call to the profession for scientific controversies to be debated in more carefully measured and objective terms
- significance of environmental problems: there is a strong recognition of the importance of environmental threats, that addressing these is everyone's business and that actions required may involve "big changes in our way of living"·environmental sacrifices are for others: in juxtaposition to the last point, pupils would not support solutions involving "sacrifice of many goods" nor is there much interest in learning more about environmental issues, let alone in careers in this area
- opposition to animal research: only 36% of pupils agreed that it was right to "use animals in medical experiments if this can save humans" and 72% think that animals should have the same rights as people

Interest in learning about science

- disappointing overall interest: asked about their interest in 'learning about' each of 108 topics covering a very wide range of applications of science, negative ('not interested') responses outnumbered positive reactions
- topics with a personal or human interest dimension attract much more positive interest: seven of the 'top ten' most favoured topics concerned human health and condition, and the other three had dimensions related to potentially exciting personal experiences
- space topics rated second in overall interest: here there were substantial differences with gender, course of study and the number of books at home – enthusiasm is higher in boys than girls, for pupils taking multiple science subjects or the higher level syllabuses, and for those with more books at home
- topics rated as most uninteresting of all included the basis of manufacturing technologies such as detergents or crude oil, the lives of famous scientists, and anything to do with plants or cultivation methods

Reactions to science at school

- not engaging less able pupils: in general, conventional school science topics provide little motivational interest for pupils taking SG Science or Int1 courses
- general low rating relative to other subjects: only for those studying the three sciences do a majority "like school science better than most other subjects"
- impact of the scientific approach: only those studying three sciences, those taking physics and chemistry, and in the highest 'books at home' categories have majorities accepting that school science has taught them to think more critical
- negative reaction to primary science: pupils rate primary school science as neither interesting nor a good preparation for secondary which was rather surprising but we are told that this group of pupils would not have had the advantage of the investment of science equipment in primary schools which later cohorts will have
- support for more practical work: there was very strong support for the benefits of practical work, and a view that expanding practical programmes was likely to increase interest in school science

Career ambitions

- priority attached to job satisfaction: pupils as a whole ranked very highly the importance of a 'meaningful' job, in keeping with their attitudes, making use of their abilities, building their skills and with an element of autonomy – these factors were somewhat less stressed by those with fewest books at home or studying less demanding courses
- importance of life outside of work: the only factor outweighing the above issues for almost all groups was making 'lots of money'; also of general high priority was that work should leave plenty of time to spend with family, friends and also on their hobbies and activities
- low interest in STEM-based careers: huge overall majorities rejected the idea of becoming "a scientist" and girls were equally averse to "a job in technology" – for the first proposition only the three science group gave a net positive response and, for the second, only those taking physics plus chemistry
- two distinctive factors for boys with fewest books at home: this group ranked "becoming the boss" and "working with machines or tools" substantially more highly than pupils as a whole

Out of school experiences and activities

- popular activities using modern technology: almost all pupils regularly use mobile phones, play computer games, access the internet, download music, use a word processor and send email - boys are relatively more involved with computer games and girls with mobile phones

- practical creative activities: boys more often engage in mechanical pursuits whereas girls engage relatively more with crafts and the natural world
- science centres: 82.4% of pupils indicated that they had visited a science centre once or more often; 89.8% of pupils surveyed had visited a zoo

We believe that there is significant information from this exercise that can usefully inform future strategies:

1. ***Messages for curriculum designers***: We believe there are significant messages in the data that could usefully inform reviews of science and technology curricula. Some of these are discernable from the analysis in the Report, but to derive the full potential benefits, significantly deeper and more detailed analysis would be required.

2. ***Further analysis of the data for each school***: We have aggregated the data for each participating school, and each of the supervising teachers has filled in a separately designed questionnaire. Our findings show evidence for significant 'class group effects'. The teacher survey has yet to be analysed, and useful further insights may be gained on integrating its information with the analysis by class group.

3. ***Messages for 'Science & Society' strategy development***: The ROSE evidence could be intelligently used to influence strategy and planning by the wide range of organisations dedicated to the promotion of appreciation and understanding of science. This survey can provide starting evidence and ideas, which in general would probably need to be followed up with smaller scale and more narrowly focussed surveys, covering, inter alia, a wider age range.

4. ***Strategies to engage those currently alienated***: This can be pursued at various levels. We have looked briefly at different ways of grouping pupils to help inform such strategies and believe that further work along these lines could be useful.

5. ***Devising approaches to challenge negative attitudes to science***: Some issues that many believe are important to economic and social development attract substantial public hostility, and these also tend to be areas which pupils are intensely uninterested in learning about. We suggest that there may be ways to approach such issues, using topics viewed as much more attractive to introduce them.

4.4 The SCDI Science and Technology Education Paper

Published in January 2007, this report by the Scottish Council for Development & Industry[40] mirrors many of the concerns that we have found on conducting our surveys in industry and also in the universities. We have included it in this section as it presents a rather integrative case. It emphasises concern about the declining numbers of young people studying science and engineering and suggest that the root of the problem stems from the falling numbers of pupils taking these subjects at school. They argue that the future success of the Scottish economy depends on a sufficient supply of suitably qualified school leavers.

They make the following recommendations with which we concur wholeheartedly:

[40] 'Occasional Paper', Science and Technology Education, January 2007, SCDI

- The Executive must properly assess the future needs of the economy for scientists and champion the sciences, particularly the Physical Sciences.
- Starting in primary school, there is a need to address the misconceptions about the subjects, such as that they are extremely difficult and/ or for boys.
- Consideration of innovative approaches to recruit well-qualified science and technology teachers, such as 'golden hellos'.
- Continued investment in Scotland's science centres, museums and science festivals, which survive on shoestring budgets.
- Developing the content of the curriculum to increase the relevance of these subjects to young people through more hands-on, practical work.
- Better marketing by professional bodies to young people of the increasing employment prospects of graduates in science, mathematics and engineering degrees.
- Better links between the education sector, government and professional bodies.
- Proper remuneration for scientists and engineers to reflect the high value Scotland places on them.

The paper goes on to note that, in the past decade, there have been falls in degree enrolments of 21% for Physics, 34% for Chemistry and 21% for Electrical and Electronic Engineering. This has led several institutions to close Departments. In FE the situation is worse and not many colleges continue to run science related HNC/Ds. One of the reasons for this is the way science courses are funded. The funding weighting is less than the average for all subjects, at about the same level as for Business Studies courses, which are cheaper to run. Engineering courses are also in decline in FE colleges with enrolment falls of 13.8% in Electrical Engineering, 42.6% in Electronic Engineering and 21.6% in Civil Engineering.

According to the SCDI report the effect of these declines is being felt by Scottish employers both at the graduate level and for school leavers. Skills gaps have been evident from employers surveys and the example given is the IET survey of a range of businesses showing that 40% did not expect to meet their engineering and technician recruitment needs over the next four years.
In other sections of this report we have also highlighted these concerns both in regard to HE and FE enrolments.

4.5 Student views of the science curriculum in England

This survey[41] carried out in England by school pupils shows what they think of their science education and how it could be improved. Below is the list of recommendations that they produced.

- Ethical and controversial issues
  The Science curriculum should include more ethical and controversial issues. These should not be hived off into occasional discrete topics but included throughout the curriculum.
- Practical Work
  Practical work should be strongly encouraged and relevant to the syllabus. The practicals need to be supervised, to work and require up-to-date equipment.
- Dissection

[41] Student review of the science curriculum, Murray and Rice, Sept 2005. School science review, 2005, 87 (318)

Schools should provide students with the opportunity to do dissection but individual students should have the choice as to whether or not they do dissection.

- Science and Mathematics
  The fundamentals of mathematics should be covered in mathematics lessons but science lessons should explicitly include a coherent treatment of the maths needed for science. Better communication is needed between science and maths teachers.
- Slimming the curriculum
  The science curriculum should cover fewer topics to allow for more in-depth treatment and for more detailed explanations.
- Discussions in science
  There should be more discussions in science classes. Discussions provide students with the opportunity to learn from someone other than their teacher and, healthily, to disagree with teachers and develop their own ideas.
- Making chemistry and physics more popular
  The popularity of chemistry and physics would be raised if they connected more with real-life situations, as biology does, and included more ethical issues.
- Primary science
  In primary school, integration between science and other subjects is important. Primary science should be placed at the same level of importance as English and Mathematics. Better equipment is needed for primary science teaching.

Most of the points raised here would also apply in Scottish schools.

5. THE CURRENT POSITION IN SCOTTISH SECONDARY SCHOOLS

5.1. Qualifications and subjects taken by school pupils

Most schools follow long-established 'Standard Grade' courses (SG), which are examined at three levels, labeled Credit, General and Foundation. Classes are generally taught in two streams the more demanding of which prepares for 'Credit / General' assessment, with others targeting 'Foundation / General'. Almost all pupils take mathematics. There are four different subject courses in science: specialist Physics, Chemistry and Biology courses are offered, though only at Credit / General level, alongside a multi-disciplinary 'Science' course, with almost all of its pupils following the lower level Foundation / General track. There are three technology related subjects offered for all levels at Standard Grade – Technological Studies, Graphic Communications and Craft and Design. There is also a course in Computing.

In 1999/2000 new curricula were launched in Scotland primarily for the S5 and S6 years, with S5 subject courses provided at three levels, Intermediate 1 (Int1), Intermediate 2 (Int2) and Higher. The lowest of these, Int1, was targeted at an achievement level comparable to 'General', whilst the Int2 course paralleled 'Credit'. The Higher course advances beyond Credit with an examination set at what is recognised as the standard university entrance level for Scotland. In a significant minority of schools the more recently designed Int1 and Int2 courses have been adopted in place of Standard Grade for teaching science subjects over S3 and S4. 'Access' courses (with levels 1-3) have also been introduced which are at a level lower than Intermediate qualifications.

Employer views of qualifications

Many of the employers participating in the project were unaware of current school qualifications and indeed some talked about O levels. Generally employers were not too conversant with Access and Intermediate qualifications and were unsure of the level at which they were pitched. The different levels within Standard Grade also often caused confusion and this may be one of the reasons employers think that qualifications do not seem to mean as much as they did many years ago.

Most employers looking for school leavers ask for specific qualifications. However, the evidence from this and other work is that many feel that their expectations of the capabilities inherent in these qualifications are not in general met. Two years ago Anne Gasteen and John Houston of Glasgow Caledonian University sampled over 300 employers to investigate how they used SQA qualifications and asked whether they regarded qualifications as indicators of skills, motivation or intellect and also the level of skills expected at different levels of qualifications.

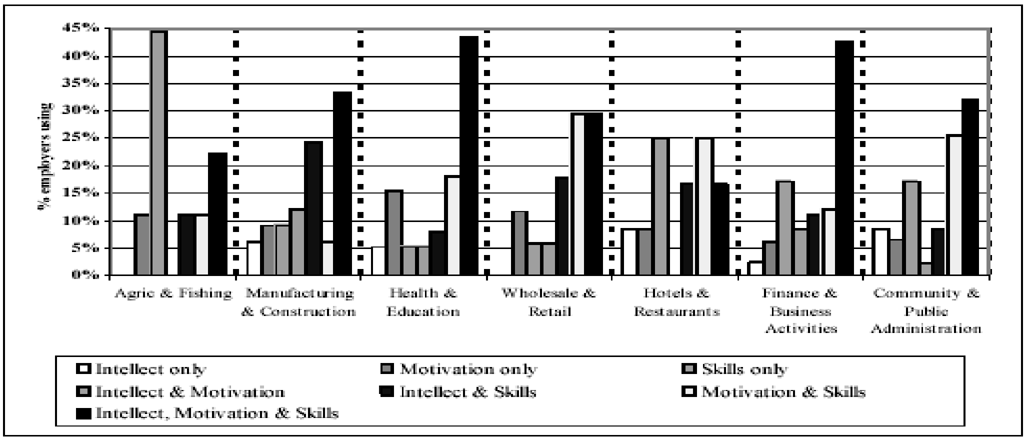
Their report[42] found that 83% of all employers used qualifications to identify skills and that the manufacturing and construction industries attached greater importance to qualifications than most other industries.

Qualifications as an indicator of motivation were regarded as a useful indicator by 67%. Qualification as a measure of intellect was used by 75% in the manufacturing and construction industries (higher than the figure of 64% for industry overall). Figure 2.10 from their report is reproduced below, illustrating the significance attached to the three characteristics by different employer groups.

---

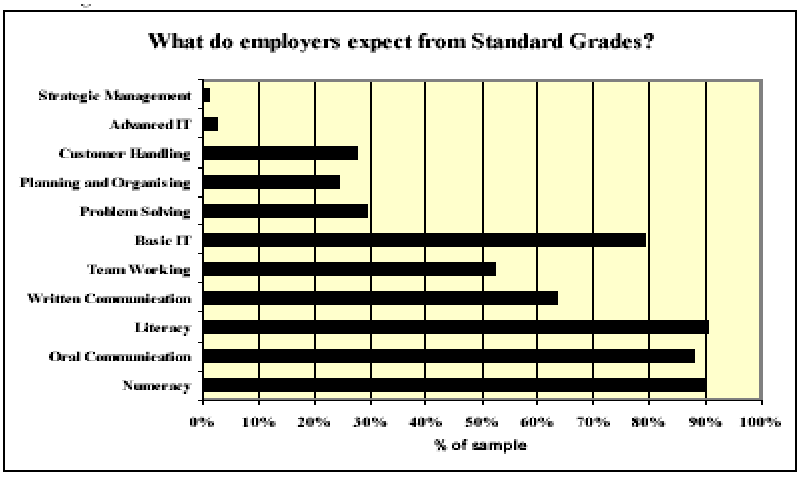
[42] SQA Bulletin number 10: *Scottish Employers' attitudes towards qualifications and skills:*. by Anne Gasteen and John Houston of Glasgow Caledonian University

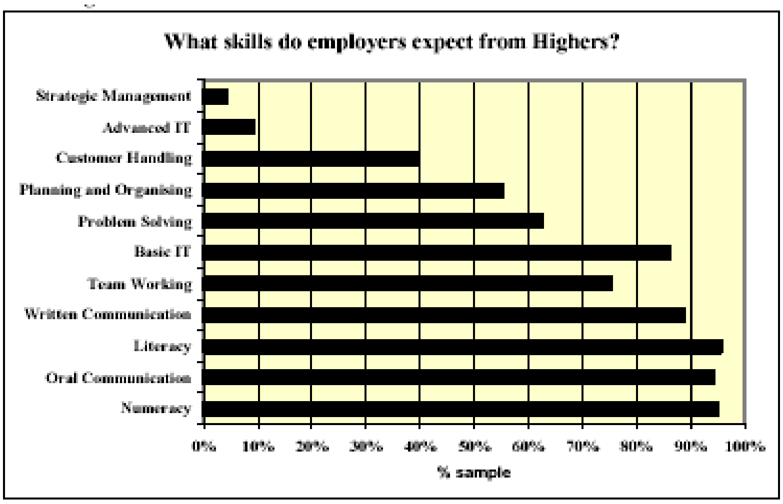
Figure 2.10 Qualifications as indicators of single/multiple characteristics



The basic skills of numeracy, oral communication and literacy were all listed as expectations of S-grade pupils by approximately 90% of employers. Basic IT, written communication and team working skills were also listed as expectations by more than half of respondents. Fewer expected problem solving to be well developed by this stage.

Reproduced are two figures from the report, showing the proportions of employers rating skills expectations from both Standard Grade and Higher Grade qualifications.





The survey indicated that 60% of employers are satisfied with the level of skills found in Standard Grade recruits, a figure that rose to 70% for Higher level. For the manufacturing/ construction sectors the satisfaction level was a little lower at SG (55%) and a little more positive for Higher (73%).

One of Gasteen and Houston's recommendations is that the SQA might consider whether its qualifications should continue to be subject based as opposed to being skills led, to reflect the levels of concern expressed by employers

5.2 Subjects studied at school and trends in uptake and difficulty

More pupils are staying on at school to take a sixth year and this has led to a more diverse range of subjects being studied. It has also meant that employers of school leavers now have the choice of selecting pupils at 16, 17 or 18 years old, with increasing numbers not offering themselves at the younger age levels.
Although more pupils are staying on until 6th Year the numbers studying the physical sciences, technological studies and mathematics at Higher level are continuing to fall. The tables below are reproduced from the recent SCDI paper [43].

Table 1: Total student entries at Standard Grade, 2000-2006:

	2000	2001	2002	2003	2004	2005	2006	% change 2000-2006
Physics	19,284 *(4.3)	19,272 (4.2)	19,678 (4.3)	19,136 (4.2)	18,170 (4.2)	16,917 (4.1)	17,064 (4.1)	-11.5
Chemistry	23,275 (5.1)	23,237 (5.1)	22,746 (5.0)	22,621 (5.0)	21,690 (5.0)	20,876 (5.1)	20,688 (5.0)	-11.1
Science	15,390 (3.4)	15,340 (3.3)	13,913 (3.0)	11,470 (2.5)	8,322 (1.9)	6,206 (1.5)	5,741 (1.4)	-62.7
Tech. Studies	3,211 (0.7)	2,739 (0.6)	2,659 (0.6)	2,244 (0.5)	2,152 (0.5)	1,921 (0.5)	1,902 (0.5)	-40.7

(Source: Scottish Qualifications Authority)
**bracketed numbers denote entries as a percentage of the overall student cohort at this level*

Table 2: Total student entries at Higher Grade, 2000-2006:

	2000	2001	2002	2003	2004	2005	2006	% change 2000-2006
Physics	10,029 *(6.1)	10,039 (6.2)	9,580 (5.8)	9,489 (5.7)	9,286 (5.6)	8.952 (5.5)	8,617 (5.4)	-14.1
Chemistry	10,103 (6.2)	9,923 (6.2)	9,560 (5.8)	9,292 (5.6)	9,271 (5.6)	9,411 (5.7)	9,168 (5.8)	-9.2
Tech. Studies	1,041 (0.6)	1,024 (0.6)	957 (0.6)	993 (0.6)	888 (0.5)	848 (0.5)	771 (0.5)	-26.0
Mathematics	20,782 (12.7)	20,730 (12.9)	19,790 (12.1)	19,966 (12.0)	19,394 (11.7)	19,191 (11.7)	18,623 (11.7)	-10.4

(Source: Scottish Qualifications Authority)
*bracketed numbers show entries as a % of the overall student cohort at this level

Although some of the fall at Standard Grade in the sciences may be due to substitution by Intermediate (Int) courses this has mainly affected the multidisciplinary Science course (through Int1 courses in single sciences). At Higher level the emergence of the Int2

[43] Science & Technology Education an Occasional Paper, SCDI, January 2007.

qualification (for S5) might have been expected to increase the numbers of Highers gained in S6. The qualification required for entry to university degrees is the Higher and so the declining numbers at this level are reducing the pool of students able to apply from school for STEM-based degree courses.

Both the absolute numbers studying Technological Studies, and their rapid decline, are causes for particular concern. Computing in 2006 had a total 0f 16,507 entries at Standard Grade, and 2245 at Higher (split between Computing and Information Systems): both of these figures are in decline.

Relative difficulty of subjects

Schools wish to encourage their pupils to gain as many qualifications and at as good grades as possible. There is some evidence of pupils being steered away from harder to softer subjects so as to gain better grades. From each year's set of results the SQA calculate a measure of the relative difficulty for each subject, called its 'National Rating'. Average ratings taken from the start of the revised Higher courses in 2000 show that, of subjects normally offered at school, Chemistry is the most difficult, followed closely by Mathematics and then Biology. At Standard Grade Mathematics still rates as difficult, but the sciences are reckoned as of around average difficulty,

Progression from S-Grade to Higher is generally thought to involve a significant increase in difficulty, for all subjects. In the sciences, this step change must be significantly greater than average, something pupils may be unprepared for from their S-Grade experiences

Relative difficulty in progression

When averaged out over 20 subjects in 1993, the chances of a candidate passing a Higher with a given Grade of Standard Grade were:

SG at Grade 1	95% achieved a Higher pass
SG at Grade 2	67% achieved a Higher pass
SG at Grade 3	34% achieved a Higher pass
SG at Grade 4	18% achieved a Higher pass

In other words candidates with a Grade 1 in a subject at S-Grade were almost guaranteed to pass at Higher and with a Grade 2 there was a two-thirds chance of a Higher pass. It has since become progressively more difficult for pupils with Grades 2 and 3 at Standard Grade to achieve a pass at Higher in the same subject.

The average figures above mask significant differences between different subjects. The table below shows that all of the STEM Highers have poorer successful progression rates than average from S-Grades of 2 and 3, and that these figures have deteriorated more dramatically between 1993 and 2002[44].

In the light of these data one can well understand schools discouraging all but the highest performing pupils from attempting science and technology Highers. It cannot surely be regarded as appropriate that a pupil who achieves a Credit award at S-Grade (albeit at Grade 2) can have barely better than a one-in-three chance of achieving even the lowest grade of pass (Grade C) at Higher in the same subject. There is evidence that some schools are beginning to offer the Intermediate 2 qualification to S4 pupils instead of Standard Grade as it is regarded as a more demanding course and may better prepare a pupil for the Higher. On the other hand more pain might be experienced in S3/S4.

[44] Progression from Standard Grade to Higher and from Higher to Advanced Higher. SQA Bulletin number 6, 2003.

Subject	Grade 2		Grade 3	
	1993	2002	1993	2002
English	82%	66%	41%	34%
Mathematics	58%	37%	21%	17%
Biology	53%	37%	21%	17%
Chemistry	59%	38%	15%	14%
Physics	51%	45%	10%	11%
Computing	60%	57%	19%	25%
Technological Studies	51%	51%	8%	17%
Economics	82%	79%	46%	63%
Art and Design	91%	79%	63%	52%
Average for 20 subjects	67%		34%	

Pass Rate for S5 Higher related to performance at S-Grade in the previous year

The performance gap between different schools

Schools inspectors have highlighted that the gap between the best and worst performing pupils in Scotland is growing despite recent high levels of investment to improve standards. This is explained as due to real improvements in standards among more able groups of pupils whilst the performance of those at the lowest level was largely remaining static. HMIE Senior Chief Inspector Graham Donaldson argued that too little attention was paid to the lowest performing 20% of pupils, a group now being targeted by the Scottish Executive concerned to increase their employability.

Factors influencing subject choice and career options

Views about how interesting a subject is, attitudes regarding its value to society and perceptions about the nature of jobs are also likely to influence subject choices. Our work on the ROSE survey gives evidence on some of these issues. Here we report some further evidence.

The Engineering and Technology Board's UK-based research paper[45] listed the following key findings.

- Mathematics and science were regarded as more challenging than other subjects
- Pupils interested in science and technology tended to come from higher socioeconomic classes but this did not apply to technology.
- Most lacked an understanding of SET careers and most saw engineering as working with machinery in a factory.
- Science attracted people who were interested in careers which involved caring for people and this may be because 80% saw scientists as helping save lives.
- Science and mathematics were more popular with boys than with girls

[45]Factors influencing Year 9 Career Choices produced by the National Foundation for Educational Research at www.etechb.co.uk/uploads/FR%20Factors%20Influencing%20Year%209%20Career%20Choices.pdf

- Their survey showed that 66% of year 9 pupils had some interest in SET careers and would benefit from more information on the wide range of careers available.
- The survey also showed that the majority of pupils are thinking about future careers at this stage when they are making their options of what to study.

A further ETB report[46] included careers survey conclusions indicating that 14 year olds did not regard engineering as a 'fashionable ' career. Less than 2% regarded engineering as their 'dream job'. The ETB report mentions a survey conducted by SEMTA of secondary school pupils in 2001 looking at their attitudes to engineering. They found that 8% of pupils would choose a career in engineering. The majority of these were boys – 17% of boys versus 1% of girls. Choosing to become a scientist was further down the list at 7% (9% of boys, though 4% girls).

One of the reasons why girls do not consider engineering as a worthwhile occupation seems to be that they consider it boring and that it involves getting dirty. Although the importance of engineering and technology to our lives was recognized the pay prospects and the interest of the work were not appreciated. Teachers also saw engineering as a dirty and old fashioned career and were unsure about the qualifications required to gain entry to engineering careers.

The main reason for choosing engineering as a career was that young people were interested in engineering and that they had a role model, often a father who was an engineer. Role models were therefore identified as an important influence on the decision to enter engineering.

5.3 A Curriculum for Excellence

Scotland is currently undertaking the largest education reform programme for a generation under the Scottish Executive's "Ambitious Excellent Schools" agenda. The report *A Curriculum for Excellence*[47] was produced in 2004 and work on decluttering the present curriculum has been progressing. The aims of *AcfE* are excellent and far reaching. Four fundamental ***purposes of education*** are identified as central to the new curriculum. These are "to enable all young people to become

- successful learners
- confident individuals
- responsible citizens
- effective contributors"

The ***principles of curriculum design*** are further identified as

- challenges and enjoyment
- breadth
- progression
- depth
- personalisation and choice
- coherence
- relevance

These purposes and principles seem perfectly formulated to allow the issues raised in this Report to be addressed.

To date work has concentrated on the early school years in most subject areas but writers have also been recruited by Learning and Teaching Scotland to produce draft experiences and outcomes for part of the science curriculum. At the time of writing (March 27th, 2007) some 30 outcomes for Planet Earth and Topical Science sections of the proposed science curriculum up to age 15 have been presented for teacher and public consultation. The outcomes are written for five levels covering "the early years", P2 to P4, P5-P7, S1+ and finally S2-S3. Teachers and

[46] *Engineering 2005, etb , Research Report November* by Roffey Park Management Institute
[47] A Curriculum for Excellence can be downloaded from http://www.scotland.gov.uk/Publications/2004/11/20178/45863

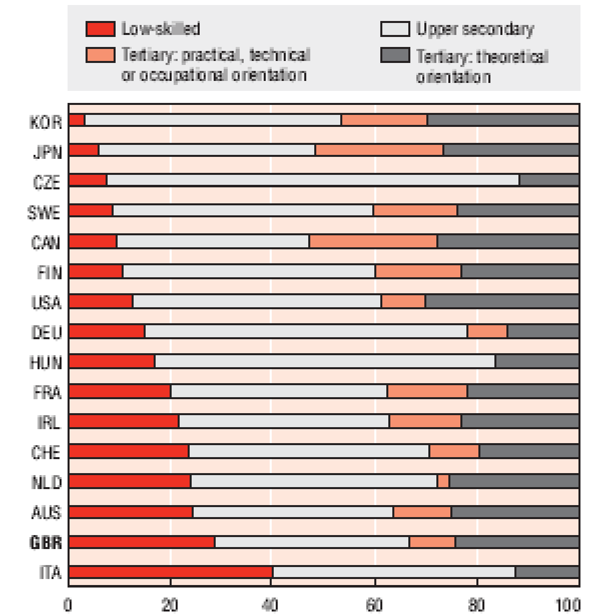
others are asked to consider how well these outcomes fit with aspects of the AcfE document, which cross-cutting themes (literacy, numeracy, enterprise etc) it will help promote and where interdisciplinary work can be linked into the outcomes. The Topical Science strand is new and addresses the science for citizenship agenda thus responding to one of the issues raised in this Report.

This review is intended to be an iterative process between interested parties and LTS which it is hoped will lead to a set of outcomes which teachers will have influenced and become enthusiastic about. What is not clear at this stage is how the "big ideas of science" are being incorporated through these outcomes, what the depth of treatment at the different stages will be and to what extent there will be interactions between science, mathematics and technology learning.

5.4 International comparisons

The OECD's 2006 OECD Economic Survey of the UK[48] shows that the UK has a large number of pupils leaving school before completion of upper secondary school and without an education giving specific competence in a professional field. While the numbers of pupils staying on at school has increased in recent years, the UK has a larger proportion of people leaving school with no upper secondary qualifications than most other comparable nations. This is the most striking point, from a UK perspective, in their figure, reproduced below.

Figure Educational attainment of the population aged 25-34 , 2003



1. "Low-skilled" comprises persons having primary school, lower secondary school or ISCED 3C short programmes as their only formal qualification. Upper secondary includes post secondary non-tertiary programmes. Tertiary type A includes type B for Czech Republic, Hungary and Italy.

Source: OECD (2005), *Education at a Glance.*

The report also concludes:

- Although schools have improved a lot during the 1990s, more could still be done to improve basic literacy and numeracy, thus giving a better foundation for continued learning. Tackling

[48] Economic Survey of the UK, 2005, OECD Policy Brief

school truancy and raising the aspirations of children from a less advantaged background is equally important.

- The number of 17 year olds in education and training in 2005 was amongst the worst in the developed world.
- The quality of vocational programmes needs to be improved and the range increased. Ways need to be found to increase the esteem in which vocational education is held if more people are to be attracted. This problem is worse in the UK than elsewhere.
- Vocational programmes and diplomas need to be rationalized and made more more attractive for pupils and employers.

International Assessment And Surveys: PISA 2000, TIMSS, AAP and ROSE

International surveys which assess groups of pupils in a large number of countries give mixed messages about Scotland's relative standing. In 2003 Scotland took part in two international student assessment programmes. The Trends in International Mathematics and Science Study (TIMSS) assessed mathematics and science achievement among a sample of pupils aged 9 and 13 in over 50 countries. The Programme for International Student Assessment (PISA) is run by OECD (Organisation for Economic Co-operation and Development) and samples 15 year olds for mathematical, reading and scientific literacy and also problem solving ability. In 2003 the main aim emphasis was on mathematical literacy. The results[49] of these surveys were published in December 2004.

PISA 2000 assessed students' capacities to apply knowledge and skills in reading, mathematics and science. Scotland performed well in this survey, coming 6th in reading literacy, 5th in mathematical literacy but only 9th in scientific literacy from about thirty countries. The results of the 2003 survey were broadly similar to the 2000 survey.

TIMSS carried out a survey in 1995 and Scotland was one of the countries taking part. At Primary 4 and Primary 5 pupils were 15th out of 24 in mathematics and 12th out of 24 in science. Results from this survey for S1 and S2 pupils showed Scotland at 27th out of 40 for mathematics and 25th out of 40 for science. At S1 and S2 their counterparts in England (10th in science) and in Ireland significantly outperformed Scottish pupils.

The results of the 2003 survey have now been published and results are broadly similar. At S1/S2 Scotland was 18th for mathematics and 18th for science out of about 44 countries. The Far-Eastern countries, some Eastern European countries, Russia, the USA and Australia all performed significantly better. At the primary 5 stage only 25 countries participated and here Scotland's mathematics achievement results were below the international average, again in 18th position. England performed significantly better at 10th position and above the international average. The science results at this stage show Scotland in 16th position with a score above the average mark and with England being in fifth position. The TIMSS report suggests that our pupils are not being stretched enough in mathematics, neither in primary school nor in the S1 and S2 years. This is also the impression gained from discussions with the university community in Scotland.

The Assessment of Achievement Programme's sixth Survey of Science 2003 tested knowledge and understanding of science for the first time and showed that fewer than 10% of the P7 and S2 pupils were 'secure' (scored 65% or over of the marks for the tasks set) at the target levels for these stages, i.e. Level D for P7, Level E for S2. 75%-80% failed to show evidence of basic attainment (scored 50% or over) at these levels.

[49] TIMSS results from http://nces.ed.gov/timss/results03.asp and PISA results from http://www.pisa.oecd.org/document/

The ROSE survey[50] is quite different to the PISA and TIMMS surveys as it is designed to test attitudes rather than scientific knowledge. The results for Scotland are reviewed above in Section 3.

5.5 Destination of Leavers from Scottish Schools

The figures from the Scottish Executive[51] for 2005/06 show that the numbers entering full-time FE or HE has risen slightly to 54%, the proportion entering employment has decreased by 1% to 26% and the proportion who are unemployed and seeking employment or training has risen by 1% to 11%. The proportion entering training outwith employment remains at 5%. One rather striking statistic is the difference in the numbers of males and females going on to HE/FE (61% for females as opposed to 47% for males). For those entering employment the difference is reversed, 31% of males and 22% of females. 13% of male school leavers were seeking employment as opposed to 9% of female leavers.

For the post school population as a whole the number of people having university and research degrees is not much different from that in other comparable countries. 24% of those in the workforce in the UK in 2002 had a higher education qualification. The figure for Scotland is higher at 28%, reflecting the higher output of graduates. There has been a significant increase in the number of women aged 25-29 with higher education qualifications in the workforce. There has been an increase from 19% in 1992 to 45% in 2002 in Scotland compared to 20% to 36% in the UK as a whole.

Migration has influenced the numbers and qualifications of the Scottish workforce for many years. Up until ten years ago there was a net outflow of graduates but from the 1990s the numbers leaving almost balanced those entering Scotland. Recently the situation has changed and there is now a net inflow of people into Scotland. Many of the jobs taken by immigrants now are at the low skilled end and many have also been seasonal in nature.

The number of people graduating in 2005 was the largest ever, with 69,885 completing a course. This figure was an increase of more than 4000 from the year before. Two areas in decline were agriculture and the physical sciences. Official figures show that since 2000, the number of students graduating with an engineering degree has fallen by nearly 30% from 7420 to 5400 in 2005 - despite the fact that engineering is one of the most highly paid profession for university leavers. This fall in numbers of engineering graduates coupled with the fall in numbers of pupils taking Higher Chemistry and Physics at school raises concerns about the future of vital Scottish industries

A recent report[52] from the Scottish Executive, *Supply and Demand for Science Graduates* paints a much rosier picture of the supply, reporting a healthy growth in the numbers entering university science courses. Over the past 8 years, as Figure below (taken from the Report) shows the numbers of Scottish based students taking mathematics degrees have increased by 79% and for Biological Sciences by 69%. However, in that time there has been a decline of 45% in chemistry, 12% for Engineering and Technology and 9% for Physics. They also note that

---

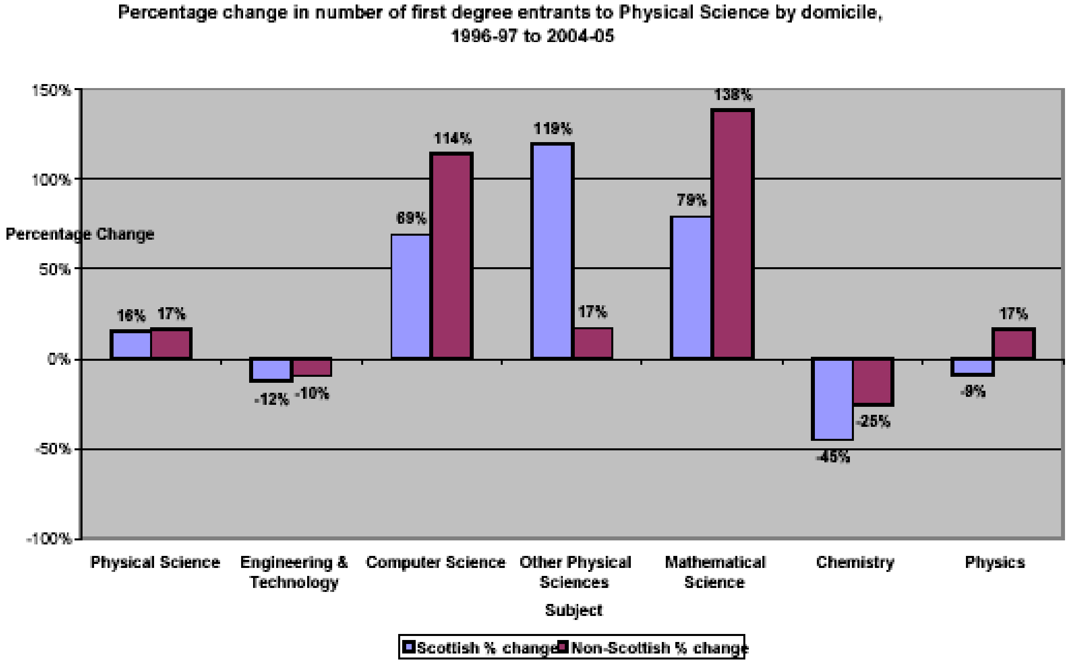
[50] The ROSE Survey in Scotland at http://www.gla.ac.uk/stem

[51] Statistics Publication Notice Education Series ISSN 1479-7569 Destination of Leavers from Scottish Schools:2005/06, December 2006

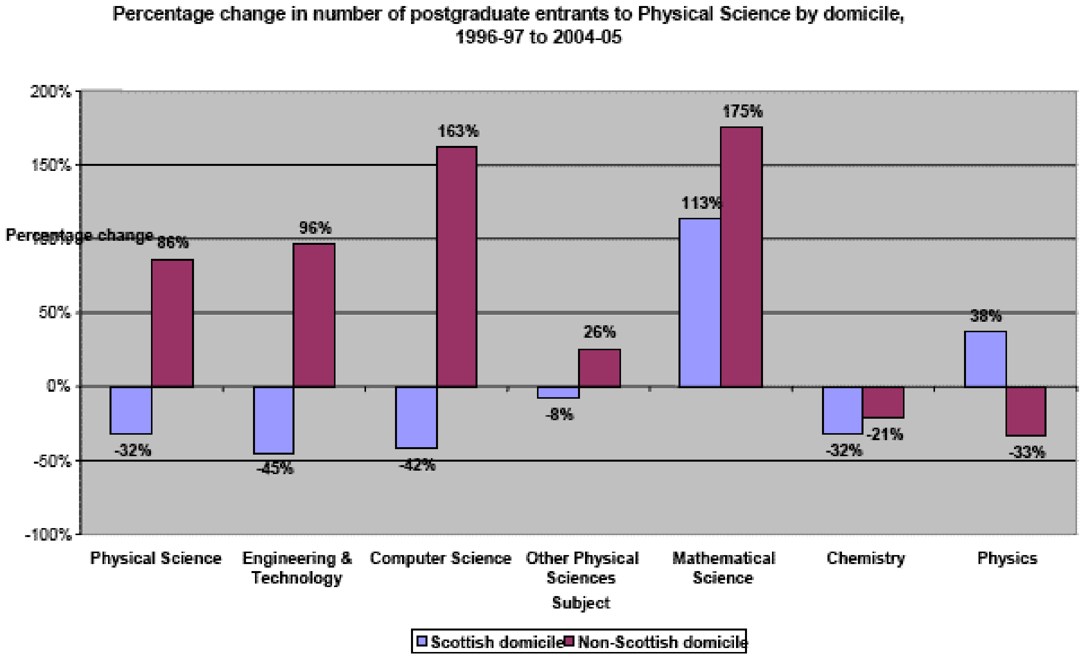
[52] Supply of, and Demand for Science Graduates in Scotland: a review of the available data, Report by the Scottish Executive, the Scottish Funding Council and Futureskills Scotland.

although the numbers of students taking 'pure' chemistry has declined the numbers taking degrees, which are allied to chemistry such as forensic science, have increased greatly.

Figure Percentage change in number of first degree entrants to Physical Science by domicile, 1996-97 to 2004-05



While the total numbers of students (see Figure below) taking post-graduate degrees in Scotland has risen in the last ten years Higher Education Statistics show that the number of Scottish born post graduate students has fallen by 565 during the that time.



More worryingly the largest declines, of 45%, have been in engineering and technology, and also in computing science. Chemistry and the physical sciences are also down, by 32%.
Alan Mitchell of CBI Scotland has commented that any sustained decline would be detrimental to the economy in the long term, while Peter Hughes of Scottish Engineering attributed the problem to schools, where fewer were studying the sciences at Higher level.

6 PROPOSED MULTI-STAKEHOLDER PROJECT ON 'GREEN FIELD' MODELS FOR A STEM CURRICULUM IN SCHOOLS

Ministers at the Scottish Executive have agreed in principle to fund the project summarised below over the next three years.

- This new project will design, present and promote discussion of new models for an optimised and coherently-linked school-level curriculum across STEM disciplines, derived afresh from 21st century perspectives.
- A core team will work through an iterative consultative process with six broadly based stakeholder networks representing teachers, industry, academics, publicly funded agencies and government.
- Four interlaced strands of work will be embraced covering: ideas & skills to be developed, major 'issues' to be explored, ordering and reinforcing key concepts & skills, and embedding external inputs.
    - The project will run over three years with completion in March 2010. Evolving proposals will be tested at 6-monthly intervals through individual consultative meetings with each stakeholder network.

6.1 Aims and Ambition Driving the Study

The drive of this exercise is to realise, in respect of education across STEM disciplines, the ambitions identified in the Scottish Executive's publication *'A Curriculum for Excellence'* to meet pupils' development as successful learners, responsible citizens, confident individuals and effective contributors.

The ambition would be that as a result of STEM education, all learners ought to

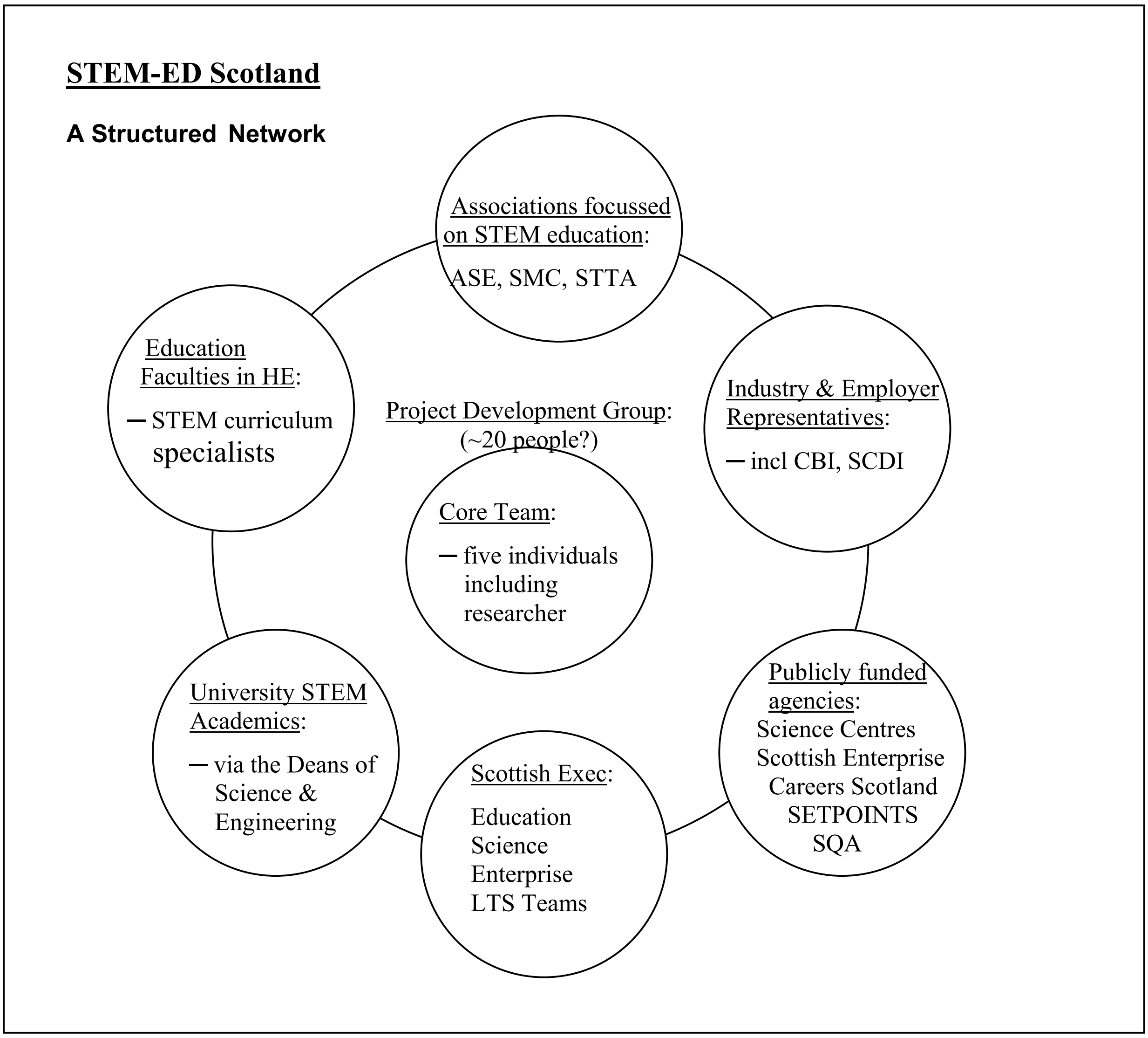
- know something of the great cultural legacy which is science: the struggle for ideas, the searches ongoing, the ways research operates the way knowledge is refined and evaluated
- be confidently 'numerate', comfortable in dealing with quantitative information, and sensitive to judging the relative significance of effects (or risks) of different scale
- appreciate some of the 'big ideas' in science: these encapsulate the main insights that drive forward scientific understanding
- appreciate the interplay of creativity, technical analysis and enterprise in designing artefacts, planning systems and solving problems generally
- be aware of the provisional nature of scientific knowledge: science is not simply a catalogue of established facts, it is a process seeking understanding shaped within the language of statistics and probability
- recognise the value of models and analogies, have experience in using scientific models and know where to draw the line between model and reality
- be aware of, and be prepared to judge the significance of uncertainties and risks inherent in making scientific predictions and in applications of technology
- be aware of the impact science & technology have had on modern wealth, health and lifestyles and of issues involved in preventing misuse of scientific capabilities
- have some understanding of the earth's systems and environment, of the past and current impact of human activity on these, and of the critical role of well-directed science to ensure sustainability
- be mindful of the continued acceleration of progress in the sciences, notably including the information sciences, and of the opportunities and regulatory challenges this will present in the coming decades

- be confident enough to play an active part in discussion and exchange on topical issues
- have experienced the challenge of finding out - of having done some science for themselves

It is highly likely that the conclusions of the project will present more than one model for a future curriculum structure. Different models could vary for instance in the degree and staging of streaming of the curriculum for different interest and ability groups and on the degree of integration across specialisms.

6.2 The Project Team and Network

The Core Team will be engaged in the direction and execution of the project on a day-to-day basis.
The Project Development Group will be structured on the lines of the multi-interest group which has prepared the groundwork so far. It will hold three-monthly meetings and relevant subgroups may be convened at other times to discuss and develop thinking and guidance on specific issues outlined in draft Paperwork from the Core Team. The Development Group will include representation of the six Stakeholder Network Groups identified in the diagram.
The planned structured network approach is illustrated in the diagram below



It is intended to engage with six Stakeholder Networks representing

- professional associations in Scotland focussed on STEM subjects with active teacher involvement
- representatives of industry and employers across technology dependent sectors in Scotland
- the STEM academic community in Scottish Universities
- public agencies concerned with STEM issues, including the Science Centres Network
- Scottish Executive representatives from Enterprise, Education and Science areas
- teacher educators in STEM disciplines, from the Education faculties of Scottish universities

The Stakeholder Network Groups will be convened through a relevant member of the Development Group, to discuss and comment on evolving analysis and proposals originating from the Core Team and Development Group. A member of the Core Team would normally participate in such discussion sessions. Stakeholder Networks will also be consulted at an individual level, through electronic communications. At the end of each year of the project a general meeting will be convened embracing all six Network Groups together.

Engaging the Industry Network and the SEED-led curriculum review

We have been asked to make particular efforts fully to engage industry in this project and will use our existing network from the Industry Project and we also hope to widen involvement. The Scottish Executive is also keen that we maintain links with the SEED curriculum review group and assist them in various ways.

6.3 A Project with Interlaced Strands

There are a number of different strands of analysis that need to be interlinked in this project as shown in the following diagram.

Strand 1: ideas and skills	**Strand 2: major issues**
A starting point would be to review the 'big ideas and skills' that school leavers from S5 or S6 might ideally have. We already have some 'subject perspectives papers' that begin to flesh this out, but these need to be integrated across STEM as a whole and must include the 'responsible citizen' perspective. These should then be considered separately for different leaving groups: intending specialists for HE, those on non-STEM professional/academic tracks, those who might go into technical modern apprenticeships etc, and the general non HE and non-technical-career oriented school leaver. We should then track downwards, looking at how each 'idea and skill' might evolve from the earliest education. The whole process would need iteration where it appears to turn out that the top aims are over-ambitious or under-ambitious.	A parallel strand might start from a review of the 'major issues' that might be explored by the end of schooling. This would be geared to give experience of a representative range of applications of science & technology, including • cases that demonstrate the impact that science has had on modern living • cases that review potential misuse of scientific capabilities (eg in terrorism) • examples that are the subject of recent or ongoing controversy • issues of future global concern • some potential future science & technology developments (including in IT) It will be important to select what can be reasonably done at different levels and by different groups.

Strand 3: ordering & reinforcing concepts and skills	**Strand 4**: embedding external inputs
This strand would analyse ways in which concept and skills development can be eased and reinforced across disciplines. Different kinds of examples are: • the reinforcement of numeracy skills through application across subjects • tracing a development path for abstract concepts and illustrating their wider value • planning contributions to the 'enterprise' agenda	This final strand might seek to identify ways in which Science Centres and other external providers could make key contributions that can be followed up and embedded in curriculum outputs. It would be important to suggest ways in which different particular inputs could be used as core to a given curriculum issue for differently situated schools

Throughout the project it will be necessary to interlace and balance these different approaches, and the whole process will require to be the subject of iteration aiming for an overall optimum outcome.

Once work on the four strands has been progressed attention will be directed to how the scheme might be 'packaged' and to possible structures within which it can be delivered. There will need to be suggested 'units' of study at various age stages and for different ability or interest streams and these should be designed to add up to a coherent package for all.
Almost certainly more than one model will be developed, though at outset it is not possible or sensible to prejudge the form of the final recommendations. Whilst this project will not get involved in writing specific outcomes for future courses at different levels we are likely to offer guidelines for possible ways ahead and to give draft outlines of potential approaches. It may be that there will be choices of units available for individual pupils and as yet we have made no decisions about how subject areas will be packaged for either the specialist or non-specialist.

6.4 Planned Process and Stages

The project will proceed through an evolving series of working papers, with 3-monthly meetings of the Development Group and 6-monthly meetings of each Stakeholder Network group. There will be an annual broader day-long conference of the whole Network together. Working papers will form the basis of each of these meetings, with agendas covering specifically identified areas as priorities for discussion.

A substantial Interim Report will be published after 18 months, and subjected to wide public consultation, culminating in a one-day open conference. The feedback from this process will feed into ongoing work leading to a more detailed final report, aimed for publication at the 33 month stage, allowing again for an active period of discussion and debate with a number of groups of stakeholders. The aim of this last period of activity will be to attempt to encourage active planning that might take forward the vision and recommendations from the project. International participation will be invited in the final one-day conference.

APPENDIX: List of Companies and Organisations involved in the study

1	Adam Smith College	Kirkcaldy
2	AG Barr	Gallowgate, Glasgow
3	Aker Kvaerner Subsea - Aberdeen	Dyce, Aberdeen
4	Alexander Dennis Ltd	Falkirk
5	Alfred Cheyne Engineering	Banff
6	Angus Training Group	Arbroath
7	AWS, Ocean Energy	Alness, Ross-shire
8	Babcock Engineering Services	Rosyth Docks, Dunfermline
9	BAE Systems Naval Ships	Govan Road, Glasgow
10	BAE Systems Regional Aircraft	Prestwick
11	Balfour Kilpatrick Ltd	Renfrew
12	Bass breweries	Glasgow
13	Baxters	Fochabers
14	BIB Cochran	Annan
15	Bioforce	Irvine
16	BP	Dyce, Aberdeen
17	Breval Technical Services	Hillington, Glasgow
18	Brimac Services	greenock
19	British Engineering	Hunterston B
20	CBI, Scotland	Robertson Street, Glasgow
21	Ciba Speciality Chemicals	Paisley
22	Clyde Bergemann Power Group	East Kilbride, Glasgow G74 5PA
23	Clyde Marine	Govan Road, Glasgow
24	Cogent	Aberdeen
25	Corrie Electrical	Stepps, Glasgow
26	Dana Glacier Vandervell	Bathgate
27	Diageo Scotland	Kilmarnock
28	Exxon Mobil Chemicals Ltd	Moss Moran, Fife
29	Findlay Irvine Ltd	Penicuik, Midlothian
30	First Engineering	Glasgow
31	Galgon	Glenrothes
32	Glaxo SmithKline	Irvine
33	Goodrich	Prestwick
34	Halliburton Manufacturing & Services Ltd	Arbroath
35	Hutcheon Services Ltd	Aberdeen
36	IBM	Greenock
37	IET Business Partners in Scotland	London
38	Improve: Food and Drink Sector Skills Council	
39	Innovene (Ineos)	Grangemouth
40	Inter bulk Investment	East Kilbride
41	Isleburn, Mackay and Macleod	Evanton, Ross-shire
42	Jacobs Babtie	Edinburgh
43	James Watt College	Greenock
44	Kemfine	Grangemouth
45	Lifescan Scotland Ltd	Beechwood Park North, Inverness
46	Lifescan Scotland Ltd	Inverness

47	Lorne Stewart	Dumfries
48	Macfarlan Smith	Edinburgh
49	Macphie of Glenbervie	Glenbervie, Stonehaven
50	Mactaggart Scott &Co Ltd	Loanhead, Midlothian
51	Matrix International Ltd	Brechin
52	McGill Electrical, Ltd	Dundee
53	National Grid Transco	Peterhead
54	National Semiconductors	Greenock
55	Northern Engineering and Welding Co Ltd	Fort William
56	Nynas UK	Dundee
57	OPITO	Aberdeen
58	Organon	Newhouse, Motherwell
59	Paisley and Johnstone Training Centre	Johnstone
60	Quintiles	Riccarton, Edinburgh
61	Rockware Glass Ltd	Irvine
62	Rolls Royce	East Kilbride
63	Rolls Royce plc	East Kilbride
64	Scottish and Southern Energy plc	Inveralmond House, Perth
65	Scottish Engineering	Glasgow
66	Scottish Gas	Edinburgh
67	Scottish Power	Glasgow
68	Scottish Water	Dunfermline
69	SELECT	Bush Estate, Midlothian
70	Shell UK Ltd	Altens Road, Nigg , Aberdeen
71	Sun Microsystems	Linlithgow
72	TTE Technical Training Group	Grangemouth
73	Tullis Russell Papermakers	Markinch, Fife
74	UKAEA	Dounreay, Caithness
75	United Biscuits	Glasgow
76	Viragen (Scotland)	Pentland Science Park, Penicuik
77	Weir Pumps	Cathcart, Glasgow